Vol. XXXVIII OCTOBER, 1928 No. 10

THE LARYNGOSCOPE

AN INTERNATIONAL MONTHLY JOURNAL
DEVOTED TO DISEASES OF THE

EAR - NOSE - THROAT

FOUNDED IN 1896 BY

DR. M. A. GOLDSTEIN

Managing Editor and Publisher.

For Contents See Page 1.

Subscription, $6.00 per Annum, in Advance.

Foreign Subscription. 35 Shillings per Annum. Post Free.
Single Copies, 75 cents.

PUBLISHED BY THE LARYNGOSCOPE CO.
3858 Westminster Place, St. Louis, Mo. U. S. A.
FOREIGN OFFICE. BAILLIERE, TINDALL & COX.
8 HENRIETTA ST., STRAND, LONDON, ENG.

[Entered at the Postoffice at St. Louis, Mo., as Second Class Matter, in July, 1898.]

THE

LARYNGOSCOPE.

VOL. XXXVIII OCTOBER, 1928. No. 10

ORIGINAL COMMUNICATIONS.

(Original Communications are received with the understanding that they are contributed exclusively to THE LARYNGOSCOPE.)

FURTHER INVESTIGATION OF THE SPECIAL SENSE-ORGANS.*

DR. MAX A. GOLDSTEIN, St. Louis.

"In the antenna of various classes of insects", writes Sir John Lubbock, "there is conclusive evidence that they function as olfactory as well as tactile organs and I believe that they serve also as organs of hearing." This observation I believe to be one of the pivotal points in the structural and physiological plan of the correlation of the sense-organs.

The sense-organs of insects have, perhaps, been more thoroughly and successfully studied than those of the other lower animals. No group offers more favorable opportunities for the study of these organs.

"No one can doubt that the sensations of other animals differ in many ways from ours. Their organs are sometimes constructed on different principles and are situated in very unexpected places. There are animals that have eyes on their backs, ears in their legs and sing through their sides. * * *

No one can read the literature relating to the organs of sense without feeling how very little we really know on the subject. Even when, as especially in the cases of organs of hearing and sight, we have careful and elaborate descriptions and figures of their complex structures, these relate rather to the separation and arrangement of the waves of sound and light, than to the actual manner in which they affect the nervous system itself; while as to the manner in which our perceptions are created we are almost absolutely ignorant."

The sense of touch seems to be the most generally distributed and from this sense the other senses appear to have been in most cases developed. In the lower order of animals the special sense-organs

*President's Address before the American Otological Society, Sixty-First Annual Meeting, Washington, D. C., May 1, 1928.

are not usually sharply distinguished one from the other and in some instances the eminent naturalists who have engaged in this delicate research conclude that the same nerve may be capable of carrying different sensations according to the structure of the end-organs.

The hairs of Arthropoda (spiders, insects and crustacea), belong to very different categories, some of which may be classified as follows:

HAIRS IN WHICH THE CHITINOUS INTEGUMENT IS ENTIRE.

a. Ordinary surface hairs; *b.* Plumose natatory hairs.

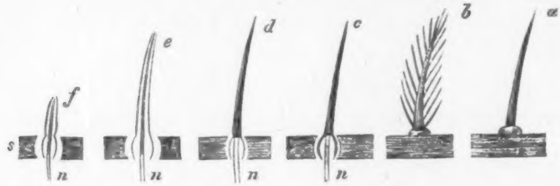


Fig. 1. Diagram of forms of hairs in insects. *a*, Ordinary surface hair; *b*, plumose natatory hair; *c*, hair of touch; *d*, auditory hair; *e*, olfactory hair; *f*, taste hair; *n*, nerve to hair.

DIAGRAM OF VARIETIES OF ANTENNAE IN INSECTS.

PLATE I.

HAIRS IN WHICH THE CHITINOUS INTEGUMENT IS PERFORATED AND A SPECIAL NERVE FIBRE RUNS TO THE BASE OF THE HAIR.

c. Hairs attached stiffly; *organs of touch.*

d. Hairs attached by means of a thin membrane, sometimes plumose; *organs of hearing.*

HOLLOW HAIRS, EITHER OPEN AT THE END OR CLOSED BY AN EXTERNAL DELICATE MEMBRANE.

e. Hairs containing a continuation of the nerve plasma; *organs of smell.*

f. Hairs generally very short and situated in the mouth or on the mouth parts; *organs of taste.*

Each of these classes is again subject to endless modifications. The sense hairs are often more or less completely sunk in the chitinous integument.

From this classification it will be noted that only slight modifications of the size, consistency, location and form of attachment of these various hairs may be found and that these modifications constitute the main differences of the several sense-organs.

Extensive monographs have been produced by Hicks and Hauser describing the minute structure of the antennae in a considerable number of insects. The greatest variety of antennal organs occurs in the Hymenoptera (ants, bees and wasps), and of these Lubbock gives a diagrammatic representation enumerating at least nine different structures. He concludes that these numerous variations in shape, size and character are due not only to the variation in habitat of the type of insect but also to the peculiar use which such insects make of their antennae and to the economic necessities for such antennae in their mode of life.

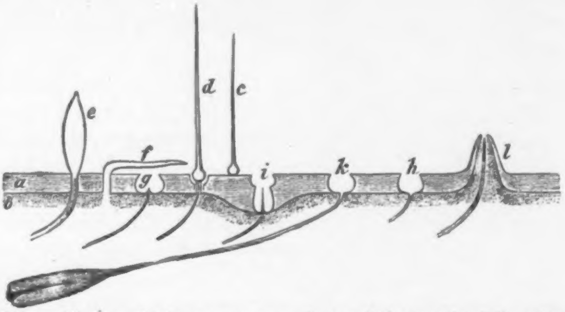


Fig. 1. Diagram showing structures on the terminal segments of the antenna of insects. *a*, Chitinous cuticle; *b*, hypodermic layer; *c*, ordinary hair; *d*, tactile hair; *e*, cone; *f*, depressed hair, lying over *g*, cup, with rudimentary hair at the base; *h*, simple cup; *i*, champagne-cork-like organ of Forel; *k*, flask-like organ; *l*, papilla, with a rudimentary hair at the apex.

ANTENNAE OF INSECTS (STRUCTURAL DIFFERENCES).

PLATE II.

The nine different structures, diagrammatically presented by Lubbock:

1. Ordinary hairs *(c)*. *2*. Hairs of touch *(d)*. *3*. Flattened hairs *(e)*. *4*. Depressed hairs *(f)*. *5*. Pits with a minute hair at the base *(g)*. *6*. Pits without a hair at the base *(h)*. *7*. Cones containing a nerve *(l)*. *8*. Champagne-cork-like organ of Forel *(i)*. *9*. Flask-like organ of Hicks *(k)*.

Hicks describes these curious flasks as "consisting of a small pit leading to a long, delicate tube, which, bending towards the base, dilates into an elongated sac having its end inverted". Lubbock states: "Of these remarkable organs there are about twelve in the terminal segment, and one or rarely two in the others. Similar structures have since been found in other Hymenoptera; but not, I believe, as yet in any other order of insects. I have ventured to suggest that they may serve as microscopic stethoscopes".

The tactile hairs on the proboscis of the fly (Musca) (Pl. III, Fig. 1) are characteristic examples of this type,—delicate, tapering, pointed hairs, inserted in a chintinous ring and attached to a nerve which swells below the skin into a multiple ganglion.

Among the Medusae (Jellyfishes), as in Lizzia (Pl. III, Fig. 2), the tactile organs are ciliated cells (a) terminating externally in a delicate cilia and internally in a nerve fibre and (g) ganglionic cell.

In Bohemilla (a small fresh-water worm) (Pl. III, Fig. 3), there are tactile cilia scattered over the surface of the integument; these hairs, even in this primitive animal, are found in two distinct groups: (c) ordinary cuticular hairs and (lb) tactile hairs with nerve ends and ganglia.

Much original and corroborative work of such accurate observers as Sir John Lubbock, J. H. Fabre, A. Forel, V. Graber, V. Hensen, T. H. Huxley, Landois, F. Leydig, Paasch, Rene A. F. deReaumur, Romanes and Slater has been accomplished during the past fifty years and it has been a thoroughly fascinating task and one of remarkable revelations to correlate these observations. The most interesting problems considered by these naturalists have been to determine in what manner external objects affect other animals, how far their perception resembles ours, whether they have sensations which we do not possess and how we, ourselves, arrive at our own perceptions.

In the lower scale of animal classification, as in the Medusae (Jellyfishes), where the entire protoplasmic surface is affected by external stimuli, as by waves of light or of sound, it is of value to note how such an organ of sight or hearing may have originated. In these animals, where the entire surface is more or less sensitive, some solid or opaque particles of pigment may be deposited in a circumscribed area, thereby creating an opacity which would arrest and absorb light, and the solidity would intensify the effect of the external stimulus. Added to this there may be a depression in the surface which would serve as a protecting element for these differentiated and sensitive cells and the secretions thrown out by such group of cells may form a more or less solid mass. This mass might be set in vibration by sound waves and thus fortify the stimulus of such a cell group. Such a body might constitute a primitive otolith or it might serve as a lens by condensing light waves and concentrating them to the underlying cell structures. Add to this the next step, namely, the development of special nerve tissue resulting from such increased and concentrated stimulus and there is created the primitive sense-organ. (Diagrams of hearing organs, primitive types, Plate VIII.)

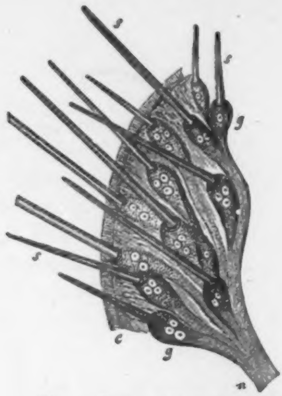


Fig. 1. Part of the proboscis of a fly (Musca) (after Leydig). *n*, Nerve; *g*, ganglionic swellings; *s*, tactile hairs or rods; *c*, cuticle.

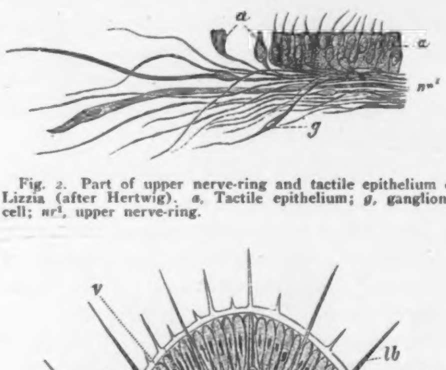


Fig. 2. Part of upper nerve-ring and tactile epithelium of Lizzia (after Hertwig). *a*, Tactile epithelium; *g*, ganglionic cell; *nr*[1], upper nerve-ring.

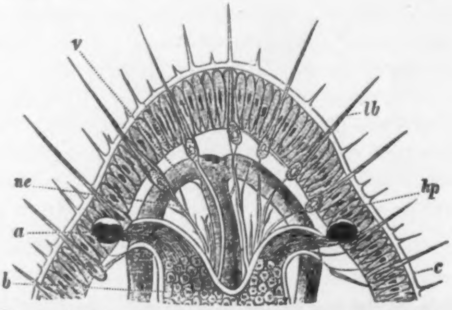


Fig. 3. Anterior part of body of *Bohemilla comata* (after Vejdovsky). *lb*, Tactile hair; *hp*, hypoderm; *c*, cuticle; *b*, anterior part of brain; *a*, eye; *ne*, nerve-fibrils; *v*, anterior blood-vessel.

TACTILE ORGANS—PRIMITIVE TYPES.

PLATE III.

These theories have been substantiated by the actual discovery of such primitive organs. In the Patella (Limpet) (Pl. IV, Fig. 2), on the outer side of the tentacles where the eyes are situated in more highly organized species, are certain spots which may be regarded as a very rudimentary organ for the perception of light. The skin is depressed into a pit within which epithelial cells of elongated and pigmented character are found. These cells resemble, in their structure and arrangement, the rods and cones of the more highly organized retina.

In the Helix (Snail) (Pl. IV, Fig. 3), the eye is more highly organized. It consists of a cornea which lies immediately below the skin; a lens, behind which is the retina consisting of three layers. Such a general arrangement seems to be common in most mollusca. The power of vision created by such an eye can be but slight and it is probable that such an animal can distinguish little more than degrees of light. If the development of the eye of an individual snail be watched in the egg it will be found to pass successively through stages similar to those herein described.

"The tissues of the lowest animals have been shown to contain a special nerve fibre, but underneath those parts of the surface where the effects of certain stimuli are heightened by the structural modifications there would be a tendency to the specialization of exceptionally sensitive tissue." Such a rudimentary sense-organ may serve either as an eye or an ear, depending on the external stimulus of a light wave or a sound wave conveyed to it. The marginal bodies running around the edge of certain Medusae (Jellyfishes) (Pl. IV, Fig. 1), have been so regarded. The supposed tactile organs contain ciliated cells which scarcely differ from other epithelial cells but which terminate externally in a cilia and internally in a nerve-fibril.

Many interesting experiments have been made with insects to determine the sensitivity of the antennae as organs of taste. Kraepelin has described, at the end of the proboscis of the Humble Bee (Bombus), besides the hairs of touch, certain peculiar club-shaped hairs, perforated at the end and which he considered to be taste hairs.

Fig. 1. *Eutima gigas* (after Haeckel). *a*, Marginal bodies.

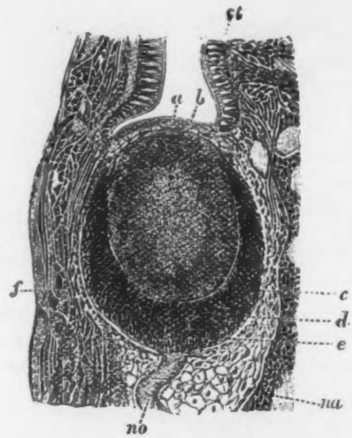


Fig. 3. Eye of Helix pomatia (after Simroth). *ct*, Cuticle; *a*, epithelium; *b*, cornea; *c*, envelope of the eye; *d*, cellular layer; *e*, fibrils of the optic nerve; *f*, feeler cell; *na*, nerve of the tentacle; *no*, optic nerve.

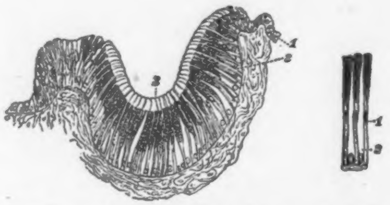


Fig. 2. Perpendicular section through the eye-pit of a limpet (Patella); after Carrière. 1, Epithelial cells; 2, retina cells, 3, vitreous body.

PRIMITIVE SENSE ORGANS.

PLATE IV.

In Pl. V, Fig. 1, is illustrated the base of the tongue of the humble bee (Bombus), showing a group of minute pits which Wolff described and considered as the organs of smell but which Forel and Will regard as more probably associated with the sense of taste.

These taste-cups, shown enlarged in Fig. 3, emphasize their character as sense-organs and include (R and R) sensory pits and hairs in a chitinous ring or cup and (G) nerve ganglia.

Another beautiful example of differentiation of sense-hairs is found in Pl. V, Fig. 2, illustrating the left maxilla of the wasp (Vespa), in which protecting hairs (shm), tactile hairs (Tb), and taste-cups (Gm), are sharply compared. In Fig. 4 there is an enlarged section of an individual taste-cup.

The taste-organ of the fly (Musca Vomitoria) is shown in Pl. V, Fig. 5, and contains nerve, ganglion and sensory capsule or cone.

Kraepelin differentiates four kinds of hairs on the proboscis of the Fly: *1.* Ordinary hairs which are not hollow and do not stand in connection with a nerve; *2.* Hairs of touch, principally situated on the upper side, delicate, hollow and pointed, situated on a ring of the integument and connected with a nerve; *3.* Glandular hairs, larger than the former; the chitinous ring is sometimes so much developed as to form a short cylinder surrounding the base of the hair. The principal characteristic, however, is that the hair presents along one surface a deep furrow and is connected at the base with a gland; *4.* Taste-organs. These lie in a row between the trachea-like channels; each resembles a double circle which scarcely projects beyond the general surface, which he too regards as a metamorphosed hollow, perforated hair. At the base of each hair is a nerve, which, at some little distance, forms a multicellular ganglion, the sheath of which, immediately below the skin, forms a delicate and short but well marked chitinous cylinder (Pl. V, Fig. 5). Even from these brief references we may conclude that the organs of taste in insects are certain modified hairs situated either in the mouth itself or on the organs immediately surrounding it.

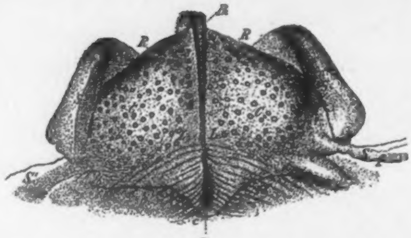


Fig. 1. Taste-organ of the bee (after Wolff). *B*, Horny ridge; *R*, *R*, sensory pits; *C*, *C*, skin of the mouth; *L*, muscular fibres; *A*, *A*, muscular fibres; *S'*, *S'*, *a b c d e f*, section of skin of oesophagus.

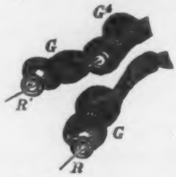


Fig. 3. Shows three of Wolff's cups, each with a central hair, a chitinous ring, and a double ganglionic swelling terminating in a nerve-fibre, X 500 times. *R*, *R'*, Sensory pits and hairs; *G*, *G*, ganglionic swelling of nerve.

Fig. 4. Section through a taste-cup (after Will). *SK*, Supporting cone; *N*, nerve, *SZ*, sense-cell.

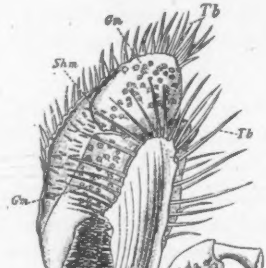


Fig. 2. Under side of left maxilla of Vespa (after Will). *Gm*, Taste-cups; *Shm*, protecting hairs; *Tb*, tactile hairs; *Mt*, base of maxillary palpus.

Fig. 5. Organ of taste of fly.

Taste Organs in Insects.

Plate V.

Leydig, in his work on the Daphnidae, confirms the observations of the correlated organs of touch and smell in the antennae. He distinguishes three kinds of hairs:

1. Ordinary, stiff, cylindrical, tapering, pointed hairs which are not connected with a nerve.

2. Pale cylindrical hairs with a blunt termination and a tuft of fine hairs. These hairs are connected with a nerve and Leydig regards them as *organs of touch*.

3. Peculiar cylinders of which there is one to each segment. They are composed of three parts, the middle one somewhat wider than the others. At the free end a group of very fine, short hairs are found. At the base of each cylinder is a nerve which apparently swells into a ganglion. They have obviously some special function and Leydig concludes that they are *olfactory organs*.

Pl. VI, Fig. 2, illustrates the marked differences in the antennal hairs of the water wood-louse (Asellus Aquaticus), *a*. ordinary hairs, not connected with a nerve; *b*. sensitive, *tactile* hairs with nerve attached; *c*. chitinous, hollow cylinders composed of a bulged central part, a terminal opening and protruding fine hairs,—which he calls *olfactory* cylinders.

Leydig also observes that in certain species of Asellus which live in subterranean waters, and have lost their eyes, these olfactory cones are usually developed.

In another insect type, the centipede (Julus terrestris) (Pl. VI, Fig. 3), the character and comparison of these olfactory cylinders with the ordinary hairs on the same antenna is very marked.

In the antenna of the blow-fly (Pl. VI, Fig. 4), Hicks found no less than 17,000 perforations, each leading into a small sac, and a number of large orifices leading into confluent sacs. At the base of these larger sacs are a number of small hairs. In many cases he traced a nerve to the base of the sac or pit. The long, stiff hairs serve as tactile hairs; the sacs or pits and their contents are olfactory organs.

In the bee the sense of smell is by no means highly developed yet their antennae are among the most highly organized in insects. They possess, besides 200 cones, which probably serve for smell, as many as 20,000 pits and it would certainly seem unlikely that an organization so exceptionally rich should serve for a sense so poorly developed.

Fig. 1. Antenna of *Pontella Bairdii* (Lubbock).

Fig. 2. Terminal segments of one of the smaller antennae of the water-woodlouse *(Asellus aquaticus)*, X 500 (after Leydig). *a*, Ordinary hairs (not connected with a nerve); *b*, sensitive hairs (with a nerve at the base); *c*, special cylinders (olfactory cylinders).

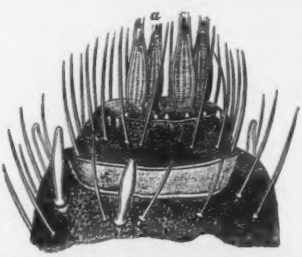


Fig. 3. Tip of the antenna of a centipede *(Julus terrestris)*, X 600 (after Leydig). At the apex are four olfactory cylinders, a few of which are also seen on the following segment, among the ordinary hairs.

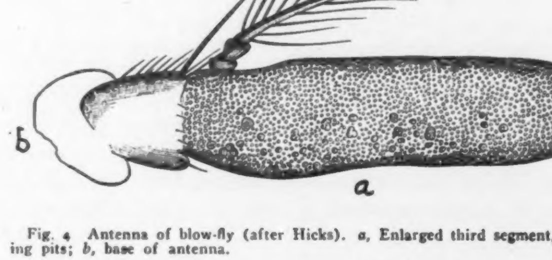


Fig. 4 Antenna of blow-fly (after Hicks). *a*, Enlarged third segment, showing pits; *b*, base of antenna.

PLATE VI.

OLFACTORY ORGANS IN ANTENNAE.

In vertebrate animals the peripheral organ of smell is embedded in the mucous membrane of the nose; in mammalia it can generally be distinguished by its yellow or brownish color; in birds it presents no peculiarity to the naked eye. The most valuable contributions on the microscopic structure of the olfactory sense-organ have been made by Max Schultze. In man the cylindrical epithelial cells in the mucous membrane of the nose terminate in broad, flat ends. Between them are rod-like filaments which expand into a ganglionic cell and terminate in a nerve-fibre. Schultze terms these *Olfactory Cells*. In birds and amphibia the olfactory cells terminate in fine ciliae or olfactory hairs, either one or many to each cell. From the structure alone of such terminal hairs there is no satisfactory conception as to how an impression of smell is conveyed or how various odors are differentiated.

The four theories which have been advanced concerning the location of the sense of smell in insects are:

1. In the spiracles or breathing holes; *2.* in the neighborhood of the mouth; *3.* in the antennae; *4.* in different parts of the body.

The earlier entomologists (Sulzer, Lehmann, Reimarus) declared that "every organ of smell is to be sought near the orifices through which animals breathe". This viewpoint was not supported by later observers, as no special nerve supply or organ which might serve for the perception of odors, was found.

Treviranus, Wolff and Graber maintained that the organ of smell was situated in the mouth but the organs found there are claimed by Lubbock to be associated with the sense of taste rather than with the sense of smell.

Lyonnet and Newport believed that the sense of smell was in the palpi, though experiments by Forel and others proved that it is not situated exclusively in them.

Reaumur is credited with the first suggestion that the sense of smell in insects is lodged in the antenna and this view has been corroborated by many naturalists.

Another group, including Scarpa, Schneider, Kirby and Spence, Landois, Hicks, Wolff and Graber has set forth the claim that the antennae also serve as organs of hearing. It is not incompatible to infer, therefore, that the sense of smell and of hearing in the same animal may both be found in one organ, the antenna. It may also happen that when both smell and hearing organs are located in the antenna they may not in all cases be confined to this structure alone.

The microscopic study of the antennae of various types of Articulata reveals many interesting and valuable observations. The sense-hairs of the olfactory organ seem, in most instances, to be enclosed in a horny tube with a terminal opening or else these hairs project as free, flexible fibrils. In insects they are aerial; in crustacea, aquatic.

Newport regarded these pits or tubes, enclosing sense-hairs attached to nerves and ganglia, as the seat of hearing. Erichson suggested that these pits and their contents were rather to be regarded as organs of smell and his views were sustained by Burmeister and Lubbock.

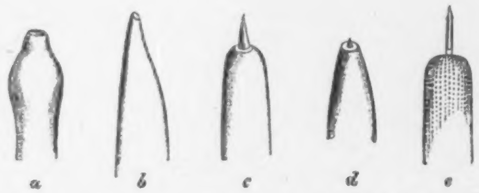


Fig. 1. Terminations of olfactory hairs of Crustacea. *a*, Of larve of a Paloemon; *b*, of a Pagurus; *c*, of a Pinnotheres; *d*, of a Squilla; *e*, of a Pontonia.

OLFACTORY HAIRS OF CRUSTACEA.

PLATE VII.

In the antennae of certain Crustacea (Pantella Bairdii) (Pl. VI, Fig. 1), Lubbock distinguishes five kinds of hairs: *1.* short, downy hairs; *2.* plumose hairs; *3.* cylindrical, tapering hairs; *4.* flattened, lanceolate hairs; *5.* wrinkled hairs,—arranged in definite situations, indicating special functions. The last two types of hairs he regarded as sense-organs.

Kraepelin describes peculiar forms of hair to which he ascribes the perception of smell, as occurring in all the stalk-eyed crustacea. These olfactory hairs vary in shape (see Plate VII) and terminate either in an open end or a small cone; some bear at their base a number of fine bristles. These hairs are undoubtedly sense organs and it is likely olfactory.

All entomologists are agreed that some of the antennal hairs serve as organs of protection and others as organs of touch. There is also much evidence that some serve as organs of smell and there is a mass of significant observations to indicate that some antennae also function as rudimentary organs of hearing.

Newport, in his profound research on the antennae of insects, writes: "These facts have convinced me that the antennae in all insects are the *auditory* organs, whatever may be their particular structure, and that, however this is varied, it is appropriated to the perception and transmission of sound." This claim, even as broad and unconditional as it has been made by Newport, finds many supporters among prominent entomologists and zoologists.

In the research work that has been undertaken since otologists have seriously concerned themselves with the sense of hearing, there seems to be a general understanding among investigators that there is the greatest difficulty in ascertaining whether an experimental animal can hear. This is due to these facts:

1. The experimental animal is often placed in an unaccustomed situation and environment;

2. It is difficult to differentiate whether such animal is affected by an actual sound or whether it is merely conscious of a tactile impression.

3. The pitch and intensity of sound produced may be entirely at variance with those to which the human ear is familiar.

There can be no doubt but that many animals, even of the lower classification, possess the power of hearing, especially as some have elaborate organs for the production of sound. It is natural to conclude that animals endowed to produce sounds must have some organ developed for the reception of such sounds. The chirp of crickets and grasshoppers and the buzz of the bee must have some significance in the activities of such insects and even in the expression of emotion, for it is an accepted observation that the respective sounds produced by such insects are known to have differences in pitch, in volume and in character. There are mating calls and notes of fear, anger or defiance to be found in these sounds. What would be the ultimate value of such variations in sound produced by an insect, or of any sound whatsoever, unless there were some provision in the species for the reception of such sounds? No insect possesses a true voice; the sounds they make are produced by wings or spiracles or by rubbing one part of the body against another. Many insects possess the power of producing audible sounds varying in pitch and intensity.

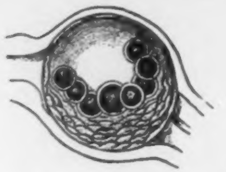


Fig. 2. Auditory organ of *Ontorchis Gegenbauri.*

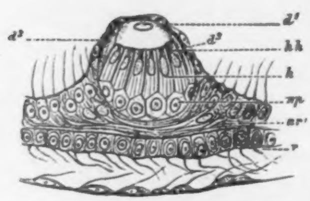


Fig. 3. Auditory organ of Phialidium (after Hertwig). d^1, Epithelium of the upper surface of the velum; d^2, epithelium of the under surface of the velum; *hh*, auditory hairs; *h*, auditory cells; *np*, nervous cushion; *nr'*, nerve-ring; *r*, circular canal at the edge of the velum.

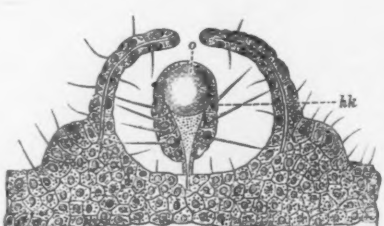


Fig. 4. Auditory organ of Rhopalonema, still showing a small orifice (after Hertwig). *hk*, Modified tentacle; *o*, auditory organ.

DIAGRAMS OF HEARING ORGANS—PRIMITIVE TYPES.

PLATE VIII.

In Pl. XIII, Fig. 1, we illustrate the leg of a grasshopper indicating at *s* on the inner side of the thigh, an even row of fine teeth which the insect rubs against the wing covering, producing thereby the familiar sound of the locust in the field. It is a form of mechanical trill or chirp of high pitch and frequently continues for 20 or 30 seconds and is recognized by most entomologists as the mating call. Pl. XIII, Fig. 2, shows a magnified picture of this even row of tooth-like projections at *s;* these teeth are stiff but possess peculiar elasticity and the intensity and pitch of sound produced is dependent on the vigor and rapidity of movement of the wing covers against these file-like ridges.

There are many variations in the mechanical appliances with which various genera of insects are equipped for the production of sound. In most instances the sound is produced by rapid movement of the muscles operating the wings or wing covers, the legs or the external abdominal area. The sounds produced by many species of flies, ants and beetles, besides the humming of the wings, are made by thin elastic sheaths attached behind each spiracle and associated with the trachea; this sheath is thrown into rapid vibration by the air during respiration.

Wollaston divides the sounds produced by beetles into three classes:

1. Incidental, such as those produced during flight.

2. Defensive.

3. Signals.

Landois summarizes six different modes in which Coleoptera (Beetles) produce sounds: tapping, grating, friction, rasping, exploding and trilling.

The hearing organs of the lower animals seem to serve modifications in function that are not characteristic of the functions recognized in man and the mammals. In fishes, the otoliths and static labyrinth are claimed to function as indicators of change of pressure in the depths of the water, the rapidity of currents and apparently aid the animal in the sense of direction.

Farre states that the otoliths in the auditory sacs of crustacea are simple grains of sand selected by the crustacea and put into their own sacs. Hensen conducted a series of interesting experiments with fresh-water shrimps, using crystals of uric acid in the water for the control of his experiments and actually saw the animals introduce these crystals into their own auditory sacs to serve as otoliths.

Fig. 2. Auditory rod of a Grasshopper. *Gryllus viridissimus* (after Graber). *fd'*, Auditory rod; *ko*, terminal piece.

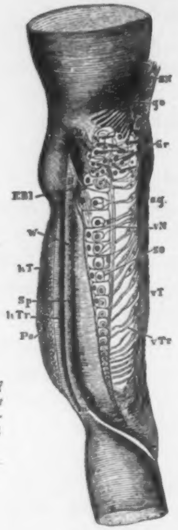


Fig. 4. Trachea and nerve-end organs from the tibia (leg) of a Grasshopper *(Ephippigera vitium)* (after Graber). *EBI*, Terminal vesicles of Siebold's organ; *hT*, hinder tympanum; *Sp*, space between trachea; *hTr*, hinder branch of trachea, *SN*, nerves of the organ of Siebold; *go*, supratympanal ganglion; *Gr*, group of vesicles of organ of Siebold; *vN*, connecting nerve-fibrils between the ganglionic cells and the terminal vesicles; *SO*, nerve terminations of the organ of Siebold; *vT*, front tympanum; *vTr*, front branch of the trachea.

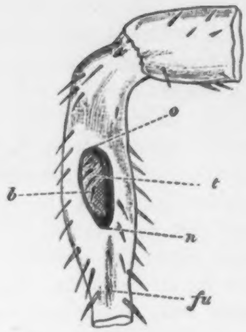


Fig. 1. Part of leg of Grasshopper *(Gryllus)* (after Graber). *o, t, n, b*, Tympanum.

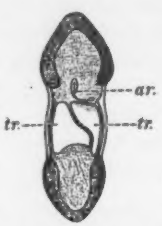


Fig. 3. Section through the tibia (leg) of a Meconema, X about 150. *tr, tr*, The two tracheæ; *ar*, the auditory rod.

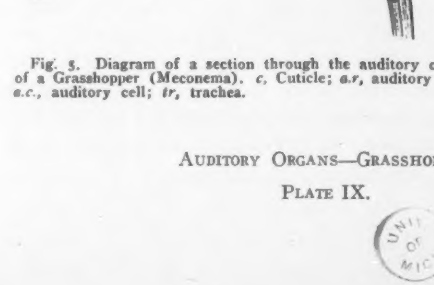


Fig. 5. Diagram of a section through the auditory organ of a Grasshopper (Meconema). *c*, Cuticle; *a.r*, auditory rod; *a.c.*, auditory cell; *tr*, trachea.

AUDITORY ORGANS—GRASSHOPPER.

PLATE IX.

Another interesting observation was carried out by Hensen in the Mysis (Fresh-Water Shrimp). In this animal Frey and Leuchart discovered that it possesses two ears *in its tail.* The tail, like that of a lobster, consists of five flaps; in each of the two smaller flaps is an oval sac (Pl. X, Fig. 3 at *a*), containing a single oval-shaped otolith consisting of calcareous matter embedded in an organic substance. Another experiment of Hensen is of interesting record. Strychnin possesses the peculiar property of augmenting the reflex power of the nerve centers. Hensen placed some shrimps in sea-water containing strychnin and found that they became extremely sensitive to even very slight noises. Attempting to verify Helmholtz's research on the perception of sound and the response of different hairs to different pitched notes, he found that this could actually be demonstrated on this small crustacea. He fixed a specimen of the Mysis so that he could watch particular hairs with the microscope; he then sounded a scale and to most of the notes the hair remained unaffected but to some it responded so violently and vibrated so rapidly as to become invisible. When the note ceased the hair became quiet; as soon as it was resounded the hair at once began to vibrate again. Other hairs in the same way responded to other notes. Hensen's observations have been repeated and verified by Helmholtz.

In insects the hearing organs are often located in peculiar positions: In grasshoppers and crickets the auditory organ lies in the tibia of the anterior leg, on both sides of which there is a disc (Pl. IX, Fig. 1 at *t*), generally more or less oval in form and different from the rest of the surface in consisting of a thin, tense, shining membrane, surrounded wholly or partially by a sort of frame or ridge. If we examine the interior of the leg (Pl. IX, Fig. 4), the trachea will be found to enlarge upon entering the tibia and divide into two branches,—*hTr* the hinder branch, *vTr* the front branch, which reunite lower down. In supplying air to this wide trachea the corresponding spiracle or breathing hole is much enlarged; associated with the two branches of the trachea are the posterior tympanum at *hT* and the anterior tympanum at *vT*. The acoustic nerve, which, next to the optic, is the thickest in the body, divides soon after entering the tibia, into branches; the supra-tympanal ganglion at *go;*

Fig. 1. Auditory hair of the crab *(Carcinus moenus)*. X 500. *a*, Skin; *c*, nerve; *h*, delicate intermediary membrane or hinge (after Hensen).

Fig. 2. Mysis (after Frey and Leuckart).

Fig. 3. Tail of *Mysis vulgaris*, showing the auditory organ.

AUDITORY ORGAN IN TAIL OF SHRIMP.

PLATE X.

the other passing down to the tympanum where it expands into an elongated, flat ganglion, known after its discoverer, as the organ of Siebold, *Gr* and *S.N.* Each of these vesicles of Siebold's organ is connected with a nerve by a fibrile *vN* and contains an auditory rod.

A magnified auditory rod is shown in Pl. IX, Fig. 2, at *fd* and the general arrangement is shown in the diagrammatic figure in Pl. IX, Fig. 5. These auditory rods may be regarded as especially characteristic of the acoustic organs of insects. A cross-section shows the position of the auditory rod in relation to the two tracheal branches as shown in Pl. IX, Fig. 3.

There are several hypotheses as to the function of this organ. Either the vibration of the tympanum may act upon the air in the trachea and so upon the auditory rods, or the air in the trachea may remain passive and the vibrations may act upon the auditory rods through the fluid in the anterior chamber of the leg.

Other peculiar positions of the hearing organs in insects are illustrated in Pl. XI.

In Pl. XI, Fig. 1, is illustrated the tibia of the Yellow Ant (Lasius flavus). The large trachea of the leg shows large sacs at the two extremities at *s* and in the course of the main trachea between these sacs at *x* is the chordatonal organ. This is a conical striated organ with fibres converging inwards and containing a uniformly arranged series of rods.

A more detailed structural picture is found in Pl. XI, Fig. 2, of the auditory organ at *cf* connected with ganglionic cells at *G* and a nerve at *n*.

In the curious club-like halteres (rudimentary hind legs of the Fly), discovered by Keller in 1764, and re-discovered by Hicks in 1856, there will be found two minute organs connected with the largest nerve in the insect (except the optic nerve), and at the base of the halteres a number of vesicles containing minute hairs or rods. These organs are regarded by some entomologists as organs of smell but by Leydig considered as organs of hearing. These auditory rods are known to occur in other parts of the body; they have been discovered not only in the antennae of the water beetle but have also been observed in the body, antennae, palpi, under lip and legs (Pl. XI, Fig. 3).

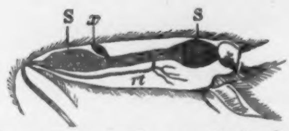


Fig. 1. Tibia of yellow ant (*Lasius flavus*), X 75. *S*, *S*, Swellings of large trachea; *rt*, small branch of trachea; *x*, chordotonal organ.

Fig. 3. One of the halteres of a fly (after Lowne).

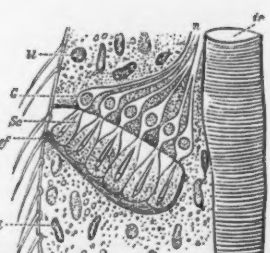


Fig. 2. Part of the tibia of *Isopteryx apicalis* (after Graber). *Sc*, Auditory organ; *ef*, terminal filament; *Cu*, cuticle; *G*, ganglion cells; *ef*, terminal filaments; *tr*, trachea; *n*, nerve.

HEARING ORGANS IN INSECTS (PECULIAR LOCATIONS).

PLATE XI.

Johnson gives an unusually detailed description of the hearing function of the hairs on the antennae of the Gnat (Pl. XII). Mayer and Hensen have made similar observations of the feathered antennae of the mosquito. As these experiments were made before the discovery of the minute structures of the contents of the ductus cochlearis by Corti, they form an interesting record and I add the description of Mayer in detail:

"A male mosquito was fastened on a glass slide and a series of tuning forks were individually sounded. With a C-2 fork of 512 d. v. it was seen that some of the hairs were thrown into vigorous movement while others remained nearly stationary. The lower fork, C-1 (256) and C-3 (1024), harmonics of C-2 (512), also caused more vibrations than any intermediate notes. These hairs, then, are specially tuned to respond to vibrations of 512 d. v.

"Other hairs vibrated to other notes, extending through the middle and next higher octave of the piano.

"I (Mayer) then made large wooden models of these hairs, and, on counting the number of vibrations they made when they were clamped at one end and then drawn on one side, I found that it 'coincided with the ratio existing between the number of vibrations of the fork to which co-vibrate the fibrils'. It is interesting to note that the hum of the female gnat corresponds nearly to this note (512 d. v.), and would consequently set the hairs in vibration.

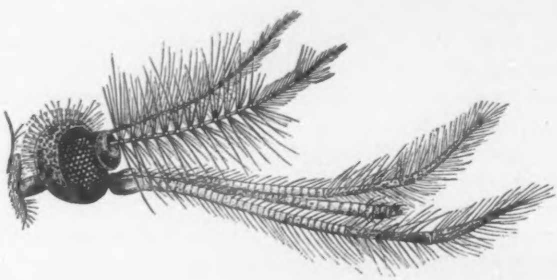
"Moreover, those auditory hairs are most affected which are at right angles to the direction from which the sound comes. Hence, from the position of the antennae and the hairs, a sound will act most intensely if it is directly in front of the head. Suppose, then, a male gnat hears the hum of a female at some little distance. Perhaps the sound affects one antennae more than the other. He turns his head until the two antennae are equally affected, and is thus able to direct his flight straight towards the female."

Observations and research undertaken to determine the limitations and character of sounds produced by the lower animals are seriously handicapped by the limitations of our own hearing capacity and there is no doubt that there are many sounds produced in animal nature, especially those of high pitch and slight volume, which cannot be detected by the human ear.

This brief survey of the special sensory-organs, as found in the natural history of the articulata and other lowly animal structures, serves two purposes: It points out the fact that even in the lowest

forms of organized animal life there is not only a provision for some form of sensory equipment by which the animal gets contact with its surroundings, but also defines differentiations of sense-organs and structural details of their reception and appreciation.

We have found that in the same animal genera one species may reveal a sensory organ that functions as an organ of sight, while in another species of the same group, but with different environment and geographical location, an organ of the same or similar structure may function as an organ of hearing. In fact, it has been shown that the rudimentary eye and the rudimentary ear in certain insects have almost the same anatomical formation and still a different physiological reaction may be demonstrated.



HEAD AND ANTENNAE OF GNAT.

PLATE XII.

In the antennae of various insects, the structural character and position of the antenna may be the only factors to indicate the differentiation in function. Even the same antenna may function as an organ of touch, of smell and of hearing.

When minutely analyzed these antennae and sensitive hairs as found in insects and crustacea, and even in the vibrissae of certain fishes and mammals, show very little variation in fundamental structure. Just as a cell is composed of a nucleas, a mass of protoplasm and enveloping membranem, so every type of sensitive hair which figures so conspicuously in the role of contact-agent between an animal and its surroundings is composed of a more or less flexible shaft, connected by a nerve fibre with a ganglion cell and eventually with the cerebral ganglia.

Much as these antennal organs differ from one another in form, arrangement and structure, they are all reducible to one type,—to a hair more or less developed, more or less deeply seated, connected with a ganglion cell and so with the cerebral ganglia.

Another interesting deduction that seems to be fairly proven by observation and experiment is that certain of these antennal organs, simple as their structure may appear, have surprisingly complicated functional possibilities (Hearing organ of Gnat, Pl. XII).

In all animals, even among the lowest classes, the sense of touch seems to be the most diffusely distributed. Furthermore, other of the special sense-organs in insect types seem to be definitely the outgrowth of more or less localized tactile organs.

This localization and specialization of structure as an organ of hearing or an organ of smell does not necessarily presuppose more highly organized or more complicated sensory organs. A slight difference in the shape, position or arrangement of an antennal hair may make a difference in function in the same animal for the sense of touch, of smell or of hearing. In fact, the same antennal hair may serve several special functions. All of these structures when analyzed into elemental forms, seem to possess one fundamental function, namely, to receive and transmit a wave of motion by means of some modified tactile stimulation.

Heat, sound, light, electricity,—all of these classic natural phenomena are but the modifications of the same wave of motion, varying in intensity, quality and direction. The impression gathered by the animal of this phenomena, then, must be as a stimulus intercepted by the sensory organs. The lower the classification of the animal in its anatomical, physiological and economic zoological rank, the simpler and more rudimentary are its sensory organs; the higher it ranks in animal classification the more highly organized and more definitely specialized are its sensory functions.

The practical application of these anatomical and physiological principles has found a significant outlet in various forms of intensive training in the handicapped child, having for its prime object increased stimulation of the organs of special sense, either individually or collectively.

In hearing we have the physiological measurement of sound from 16 d. v. to 30,000 d. v. and yet we know that there are definite sound vibrations of a speed beyond this limit that may have a sensory reception.

The standards of normalcy which have been adopted for the measurement of the capacity of sight, hearing, taste, smell and touch are but arbitrary and based on the law of averages. A limitation of efficiency and performance in any one or more of the sense-organs of the human has not yet been reached.

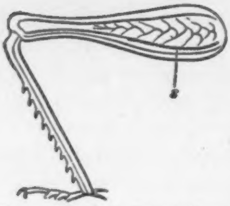


Fig. 1. Leg of *Stenobothrus prætorum* (after Landois).

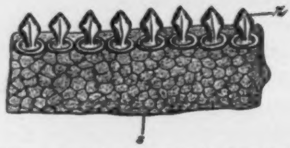


Fig. 2. Sound-bow of *Stenobothrus* (after Landois). *s*, Surface of the skin; *z*, teeth.

SOUND APPARATUS OF GRASSHOPPER.

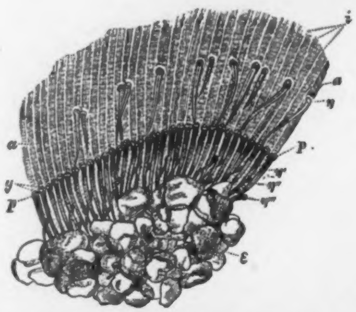


Fig. 3. Part of wall of auditory sac of lobster *(Astacus marinus)* (after Hensen). *a*, Thickened bars in the membrane of the sac; *n*, first row of auditory hairs; *n'*, second row of auditory hairs; *n''*, third row of auditory hairs; *n'''*, fourth row of auditory hairs; *e*, grains of sand, serving as otolithes.

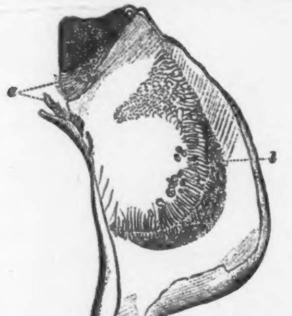


Fig. 5. Interior of auditory sac of lobster (after Farre). *a*, Orifice; *b*, auditory hairs.

Fig 4. Base of right antennule of lobster *(Astacus marinus)* (after Farre). *a*, Orifice; *s*, sac.

HEARING ORGAN OF CRAB.

PLATE XIII.

In the March, 1928, issue of the *Scientific American,* R. W. Wood writes under the caption, "The Human Ear Senses No Vibrations Above 30,000 Per Second, but Inaudible Sounds at 300,000 Vibrations Per Second Perform Queer Antics". A small tube of glass is drawn out into a long thread of glass the size of a horsehair. It is suspended over a shallow glass dish filled with oil and the terminals of a coil of wire lead down through the surface of the fluid. The thread is shaken by invisible vibrations at the rate of 300,000 per second. If the thread is held lightly between the thumb and finger nothing is felt of this tumult, but if we squeeze it, it burns like a red hot wire and we find a deep groove in the skin, with white-seared edges.

"If the end of the thread is pressed against a pine chip, the wood smokes and emits sparks, the thread rapidly burning its way through the chip, leaving a hole with charred and blackened edges. If a plate of glass is substituted for the chip the thread eventually bores its way through this, throwing out the displaced glass in the form of a fine white powder. These are a few of the many remarkable effects obtained with high-frequency sound vibrations in a series of experiments carried on by the writer, in collaboration with Mr. Alfred L. Loomis at his private laboratory in Tuxedo Park. * * *

"We have found many interesting biological effects of the vibrations. Red blood corpuscles are destroyed, the salt solution in which they are suspended losing its turbidity and becoming of a clear red color like a solution of an aniline dye. Undiluted blood is 'laked' by the vibrations, a result of interest to physiologists engaged in investigations in which a complete breaking up of the red corpuscles without the use of heat or chemical agents is desired. Small unicellular organisms, such as paramecia, are killed and the cells torn open. Filaments of living spirogyra were torn to pieces and the cells ruptured. Distinct evidence was obtained also that the red corpuscles could be destroyed within the body of a living animal (a mouse), and small fish and frogs are quickly killed by the vibrations.

"A wide field of investigation in biology appears to be opened up by these experiments. By employing the technique of the fine glass thread, it will be possible to apply the vibrations at a minute point on the surface of an egg embryo or small organism under the microscope, and study the effect of the local disturbance on its subsequent growth.

"By employing vibrations of a less intensity, which do not actually rupture the cells, the granules within them can be displaced from their normal positions without any actual destruction of tissue. It seems quite possible that results of importance can be obtained along the lines initiated by Professor Loeb, who punctured embryos with fine needle points and then studied their subsequent abnormal growth."

Osiso equipment mounted ready for operation. Revolving and tilting mirrors. Studio microphone. Meter for registration of voice intensity.

PLATE XIV.

Tactile impression may be educated in the human subject to register a delicacy of perception almost equaling the capacity of appreciation of waves of sound as interpreted by the ear, or waves of light as interpreted by the eye.

We have proven the ability of the totally deaf child to analyze and interpret the complex character of sound waves producing speech exclusively by the sense of touch with as much accuracy as is possible through the usual medium of hearing.

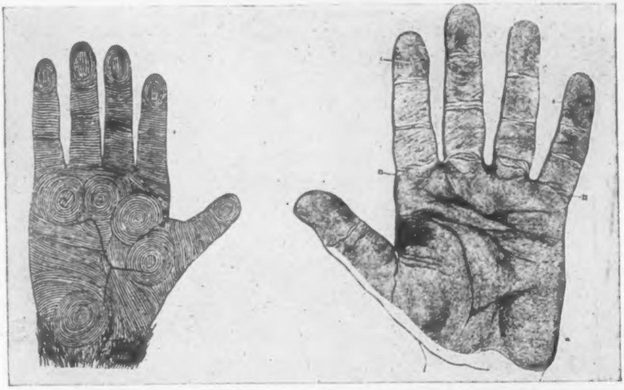
Osiso, showing teacher and pupil, usin gseparate microphones. Teacher gives model graf; pupil imitates.

PLATE XV.

We have demonstrated the translation of speech from sound waves to light grafs and the accuracy with which a deaf child can be taught to translate these light grafs again into speech.

The sense of smell and the sense of taste still show such close inter-relationship with each other that their shape, differentiation and disassociation is a matter of difficult accomplishment.

From numerous observations we have concluded that the sense of touch may be more acutely educated by intensive training than even the sense of sight or the sense of hearing. In many of the lower animals it is found that the touch corpuscles are distributed more liberally in the regions of the body by which this animal comes in contact with his surroundings than in other surface regions. In the



Hand of Chimpanzee.
Touch-bulbs in the hand of the Ape (Kollmann).

Human Hand.
Touch-bulbs in the human hand (after Hibert). *I*, first; *II*, second; *III*, third row.

PLATE XVI.

higher apes, the Pacinian corpuscles are equally developed in the hands and feet; in the human these Pacinian corpuscles are developed most numerously in the hands; in many bird species these touch organs are liberally supplied to the base of the beak; in the Batrachia they are found in the area of the lateral lines; in insects their presence is almost exclusively demonstrated in the antennae.

In addition to their distribution in the fingers of humans, touch corpuscles are also found in the entire area of the skin, on the lips and in the papilla of the tongue.

It is still a moot question where the sense of touch has its physiological limitations and where the sense of taste and the sense of smell begin. The same is true of the sense of hearing.

In our observations in the education of the deaf child and the use of the Audiometer in testing hearing capacity for even such remnants of hearing as may still be present, it is difficult to say where the zone of audition ends and where the area of tactile impression begins. The charting of the results of the Audiometer test still demands these arbitrary differentiations but so far they have proven inadequate to determine an analysis of these physical perceptions.

Dependence on the sense of touch as a pedagogic substitute for the loss of a special sense-organ is by no means a new thought. It has been used successfully by special educators in the instruction of the blind for many years; it is the basis for Braille reading, for Montessori training, for various forms of sense training in modern kindergarten work, for Binet-Simon intelligence-quotient tests, and for various psychological observations.

It should be definitely emphasized that the success of these experiments and observations may be accounted for by the fact that our system of training the deaf child today includes intensive work in sense-training, sound vibration, voice building, musical touch, rhythm and accent appreciation and a careful attention to the association of ideas in teaching oral speech, including memory, form, color and other attributes that help to determine the psychology of language.

It is a significant observation that over 30 per cent of all congenitally deaf children have some residuum of hearing. In some cases it is of so limited a degree that it cannot be practically utilized; in a larger group it remains latent because of insufficient stimulation; in all cases it should be given a reasonably long try-out, for those auditory remnants are peculiarly sensitive to stimulation and re-education and in a large percentage of cases the perseverance and resourcefulness of the teacher will be rewarded by surprisingly good results.

In conclusion I beg to offer my apologies for such liberal quotations from the works of numerous entomologists and naturalists and especially for frequent verbatim references to the monumental work of Sir John Lubbock in this unusual field. To the otologist these valuable observations have been almost unknown. Their scientific veracity is unquestioned, even though we as later investigators have not been placed in a position to practically corroborate these minute and important findings.

We are proceeding rapidly with this substitution of one sense-impression for another and in the past decade important contributions in this field have been made.

Congenitally deaf pupil receiving and repeating spoken language as given by teacher through megaphone. Megaphone, covered at larger end by tightly stretched sheet of drawing-paper; finger-tips of pupil are placed on paper disc.

PLATE XVIII.

Collectively the data gathered for these observations includes the work of some of the most astute scientific discoverers in the past fifty years. It is a fund of reference material which may serve as a valuable guide toward the upbuilding of the problems which we have undertaken to solve, namely,—how far can we proceed in our practical and scientific work in correlating the various mechanisms responsible for the appreciation of tactile impressions in their many modifications as presented in the evolution of the sense-organs throughout the animal kingdom.

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THE OSSIFICATION OF THE LABYRINTHINE CAPSULE.*

DR. THEODORE H. BAST, Madison, Wis.

The growth and development of the cartilaginous otic capsule has been presented in a very scholarly manner by Dr. George L. Streeter in the Contributions to Embryology, No. 20. The subsequent growth and metamorphosis into the bony capsule has been studied by Huxley, 1864; Ficalbi, 1887; Perozzi, 1920; Claoue, 1928, and others, but their results are conflicting. The reason for this no doubt lies in the fact that these workers did not study complete serials of the capsule and did not reconstruct them.

This report is based on the study of serial sections of the otic capsules of 25 human fetuses, ranging from 100 m.m. to 360 m.m. crown-rump length, and on the reconstruction of five of them.

In the accompanying figures the ossification centers are numbered so as to correspond to the numbers used in the text. These numbers represent as nearly as possible the order of appearance of these centers. The order, however, cannot be represented absolutely, since such centers as 6, 7, 8, 9 and 10, and even 11 and 12, all appear about the same time.

The labyrinthine capsule is cartilaginous up to about the sixteenth week in intrauterine life. The earliest ossification centres begin in fetuses of about 120 m.m. crown-rump length. The first centre develops in the region of the beginning of the first turn of the cochlea anteroventral and medial to the round window. This bone appears to protect the organ of Corti in the oldest part of the cochlear duct. The second centre guards the region of the crista ampullaris of the posterior semicircular canal ampulla. The third centre guards the cristae ampullaris of the superior and lateral canal ampullae. A fourth but minor centre develops between the first two centres, thus uniting them above the round window. The order of appearance of the succeeding centres does not seem to be uniform. Thus in a fetus of 140 m.m. Centre No. 5, which forms the bone of the lateral wall of the internal auditory meatus, is prominent and has just united with Centre No. 3. In another fetus of 147 m.m. an equally prominent Centre No. 6 lies in the medial wall of the internal meatus and is fused with equally prominent Centre No. 7, guarding the entrance

*Read at the Sixty-First Annual Meeting of the American Otological Society, Washington, D. C., April 30, 1928.

of the cochlear nerve into the cochlea. These two centres are not present in the 140 m.m. fetus. In the fetus of 147 m.m. Centres Nos. 6 and 5 are fused to form the roof of the internal auditory meatus. In this same embryo five other centres are present. One, No. 8, in the inferior medial wall of the internal meatus, which later fuses with Centres Nos. 6 and 7 to complete the medial wall of

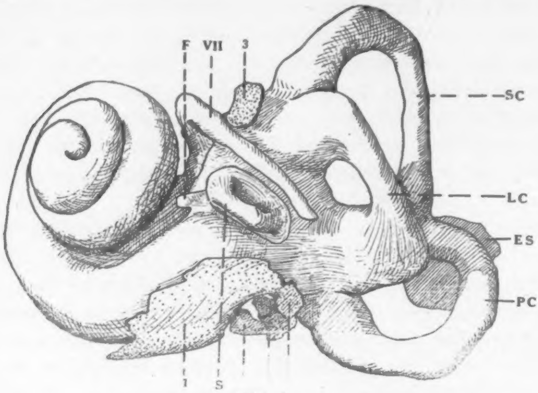

Fig. 1.

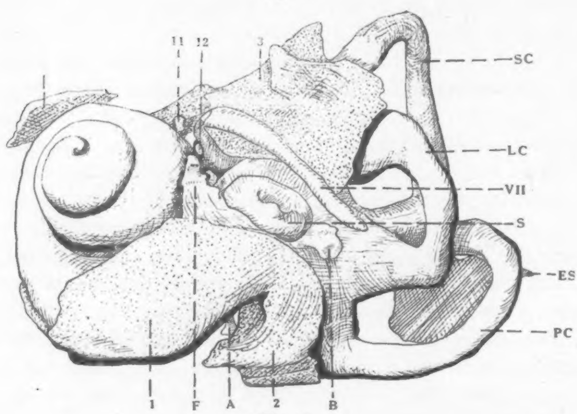

Fig. 2.

the meatus, and still later with Centres Nos. 2 and 5 to form the floor of the interna lauditory meatus. Another centre, No. 9, occurs in the capsule of the most posterior portion of the superior canal just above the endolymphatic sac. Another prominent centre, No. 10, lies in the superior medial portion of the capsule of the first turn of

the cochlea. The other two, Nos. 11 and 12, are very small and lie in the lateral and superior lateral portion of the capsule around the first turn of the cochlea. In a fetus of 183 m.m., another centre, No. 13, is started in the capsule over the most lateral portion of the

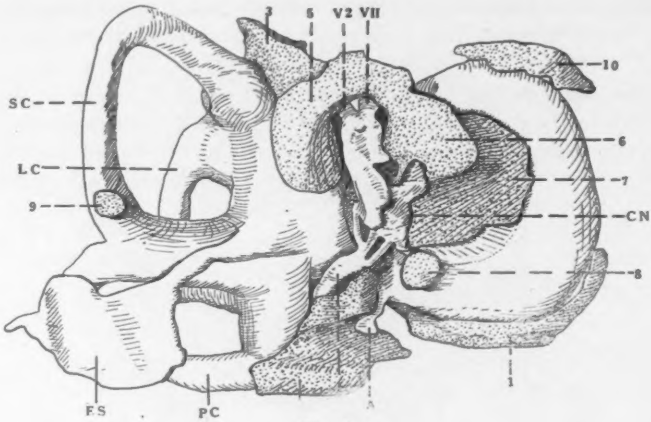

Fig. 3.

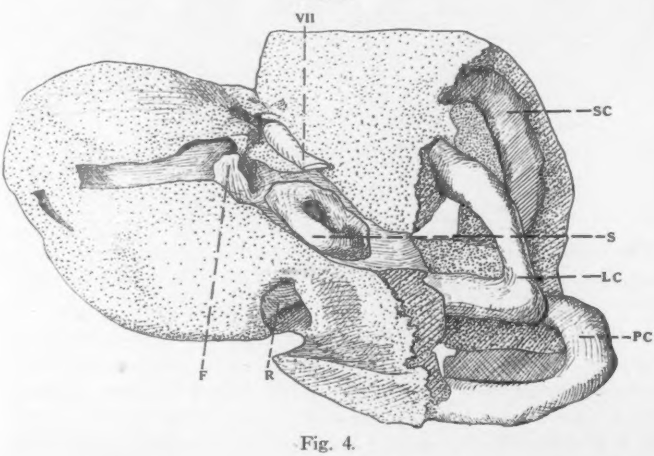

Fig. 4.

posterior canal. This centre is well developed in a fetus of 190 m.m. The lateral part of the lateral canal capsule is the last of the canilcular capsule to ossify. In an embryo of 202 m.m. there is a mass of bone in this area, but it is continuous with the rest of the ossified

capsule and it is thus impossible to determine from the material at hand whether or not this arises as a separate center. The ossification of the canalicular portion of the capsule is completed by the seventh month of intrauterine life. The last portions of the capsule to ossify are the area around the footplate of the stapes and an area anteromedial to the stapes surrounding Cozzolino's zone, or also known as the fissura anterior. This is incompletely accomplished by the fusion of Centres Nos. 1 and 3, but not until after birth.

The relatively late ossification of the canalicular portion of the capsule can be explained by the fact that the semicircular canals continue to expand after the rest of the labyrinth has stopped growth. The bony capsule develops around the canals as soon as growth ceases.

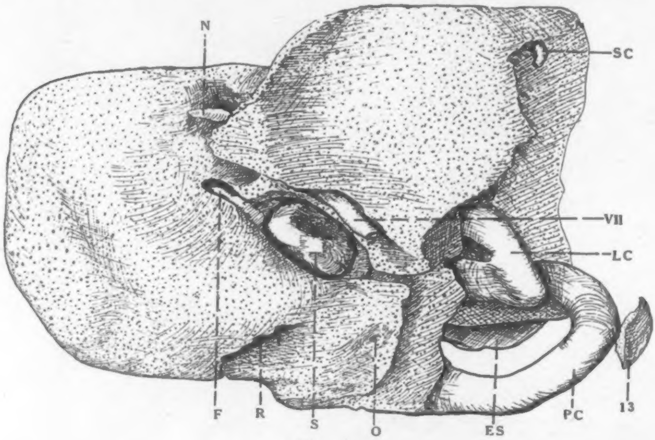

Fig. 5.

The much later ossification of the area around and anterior to the stapes cannot be explained on a growth basis. Histological examination shows that the cartilage anterior to the stapes, which is so slow to ossify, surrounds a sac-like fissure which communicates between the middle ear and the perilymphatic space at the point where the scala vetibule joins the vestibule. This fissure has been variously termed fissura anterior or Cozzolino's zone (Figs. 1, 2, 4, 5F). Fig. 6 is a photomicrograph of a section through the capsular wall anterior to the stapes showing the communication of this fissure (F) with the perilymphatic vestibule (V). Fig. 7 is a picture of a section through the capsule a little higher up showing the communication of this fissure (F) with the middle ear (M). In both of these pictures the cartilage (C) surrounds the fissure.

The tissue which fills this sac-like fissure is a loose embryonic connective tissue of the type found in the very young perilymph spaces, with which it is still continuous. It is also similar to that found in the aqueductus cochlea.

This structure, together with the late and incomplete ossification in this area may be of importance in relation to the otosclerotic patches

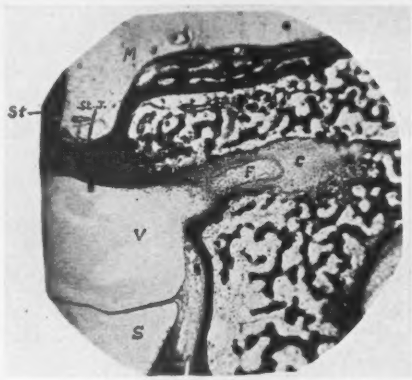

Fig. 6.

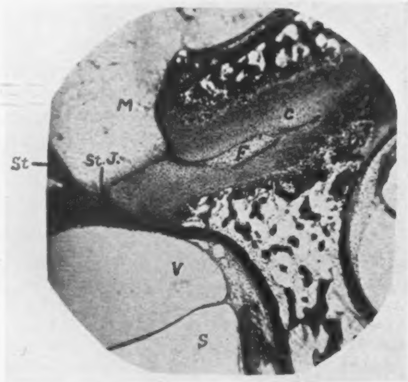

Fig. 7.

which most frequently occur in this region. It may also be a possible portal of entry of infections into the labyrinth, as pointed out by Dr. Crowe and Dr. Guild.

Another interesting structure which I have constantly found in human fetal ears is a structure which, for the lack of a better term (until its function may be determined), I have called the utriculo-

endolymphatic valve. The utriculoendolymphatic valve is a highly cellular connective tissue flap lined by columnar epithelium. It guards the utricular opening into the canalis endolylymphaticus. The valve is a fold of the posterior wall of the utricle and endolymphatic canal at the point of junction. The function of this valve-like structure has not been determined. Its position would indicate that the flow of endolymph is from the endolymphatic canal to the utricle, but this is not a necessary conclusion. If the flow is in the other direction, the slow movement of the lymph may not affect this valve. On the other hand, in case of any sudden pressure disturbance, this valve may prevent the outflow of endolymph from the utricle, thus maintaining a more constant pressure within the utricle and semicircular canals.

Explanation of Figures.

Figs. 1, 2, 3, 4 and 5 are drawings of models made by reconstructing serial sections of the petrous portion of temporal bones of human fetuses. These models are designed to show the perilymph labyrinth and only that portion of the capsule which is ossified. Bone is indicated by stippling. The fetuses from which the ears for these models were obtained were of the following sizes (crown-rump length): Fig. 1, 126 m.m. fetus; anterior view. Fig. 2, 147 m.m. fetus; anterior view. Fig. 3, 147 m.m. fetus; posterior view. Fig. 4, 161 m.m. fetus; anterior view. Fig. 5, 183 m.m. fetus; posterior view (this embryo was received from Dr. Bartelmez, University of Chicago).

Figs. 1 to 5. Nos. 1-13 represent ossification centers in their approximate order of appearance. S—Stapes. F—Fissura anterior or Cozzolino's zone. B—A structure in the otic capsule posterior to the stapes similar to the fissura anterior but communicating only with the labyrinth and not with the middle ear. Not present in all capsules. A—Aqueductus cochlea. R—Fenestra rotunda. PC—Posterior semicircular canal. LC—Lateral semicircular canal. SC—Superior semicircular canal. ES—Endolymphatic sac. CN—Cochlear nerve. V1—Nerve to the ampulla of posterior semicircular canal. V2—Nerve to the ampullae of the lateral and superior semicircular canals. VII—Facial nerve. N—Great superficial petrosal nerve. O—Foramen for capsular blood vessel.

Fig. 6. Photomicrograph of a portion of a section through the ear of a 183 m.m. human fetus showing the fissura anterior at the level where it communicates with the vestibule.

Fig. 7. Photomicrograph of a portion of a section from same fetus referred to in Fig. 6, but at a higher level where the fissura anterior communicates with the middle ear.

Figs. 6 and 7. ST—Stapes. StJ—Stapes joint. M—Middle ear. V—Perilypmh vestibule. S—Sacculus. F—Fissura anterior or Cozzolino's zone. C—Cartilage.

A FLURRY IN MASTOIDS.*

DR. LOUIS R. EFFLER, Toledo.

In this symposium on otitis media, we shall not bore you with a theoretic account of the complications that may occur. Apart from the mere mention that mastoiditis, sinus thromboses, brain abscesses, meningitis, etc., all may complicate this disease, we shall confine ourselves to a description of the complications that actually did occur in a series of private ear cases. It is one thing to discuss what might have occurred, and another to discuss what actually did occur.

Influenza in the United States has been pandemic throughout the winter. The months of March, April and May, especially, have seen a surprising number of cases. Fortunately, most influenza has been mild, or, at the worst, moderately severe. Even with these, however, there have been sufficient complications to cause concern. We shall view the situation only from an ear, nose and throat standpoint.

The total number of flu cases seen by us in private during this three-month period numbered 222. Naturally, we did not see general flu cases but only such as complained of throats, ears or sinuses. The total number of sinus complications in this series was 80. The total number of ear cases was 63. Of this number, there were nine mastoidectomies. To our great satisfaction, none developed more serious intracranial complications.

The following table gives an idea of the distribution per month of the number of flu cases in this period with their oto-rhinological complications.

TABLE I.

	Total Flu	Sinusitis	Otitis Media	Mastoidectomies
March	64	21	20	4
April	61	17	15	4
May	97	27	28	1
Grand total for three months	222	80	63	9

A study of this table (Table I) develops a very interesting fact. The total number of our flu cases for May was far in excess of the numbers for both March and April, respectively. Peculiarly, the

*Read as part of a "Symposium on Otitis Media" at the May Meeting of the Mercy Hospital Staff, Toledo, Ohio.

Editor's Note: This ms. received in The Laryngoscope Office and accepted for publication June 22, 1928.

total number of sinus and otitis media complications is also increased. There is not a serious disproportion in the various months. The outstanding feature, however, is the fact that there is only a single mastoidectomy for May, as against four for March and four for April. This is difficult to explain. Perhaps the only explanation that may be offered is that the virulence of the flu epidemic thereby showed signs of subsiding. That the fires are burning low may be further borne out by the fact that while there has not been a sharp falling off of flu cases for June, still the total number has dwindled together with sinus and ear complications. The net result has been one mastoidectomy which does not figure in this study.

March, April and May we have always considered low ebb months. There has seemed to be always a flurry of mastoids during this period. We were interested to check up the total number of mastoidectomies done in Toledo hospitals during this period. We felt that, judged from our own figures, the total number would be very high. Our surprise was genuine when we say that the total number of mastoidectomies during this period was only 32.

The following table gives an idea of the distribution of mastoidectomies at the various hospitals in Toledo during this period.

TABLE II.

Hospital	March	April	May
Robinwood	1 (acute)	0	1 (acute)
East Side	0	0	0
Flower	3 (2 acute, 1 chron.)	2 (acute)	1 (acute)
Toledo	2 (1 acute, 1 chron.)	0	0
Lucas County	0	0	0
St. Vincent's	3 (acute)	2 (acute)	2 (acute)
Wom. & Chil.	1 (acute)	2 (acute)	1 (acute)
Mercy	7 (acute)	3 (acute)	1 (acute-chron.)
Total	17	9	6

Grand total of mastoidectomies, 32.

Nine mastoidectomies are a small number. We shall make no attempt to draw conclusions from them. We shall content ourselves merely with reporting them in chronological sequence. Here and there points of interest may be met in individual cases. The chief point of interest, however, to us was the matter of no mortality. All have healed or are in the process of healing without undue delay or complications.

Case 1: H. C., girl, age 24 years, first seen on March 10, 1928. The right ear had been discharging three weeks following influenza. In addition to the copious, purulent discharge, there was acute mastoid tenderness and temperature of 99½° even at this late date. There was bulging of the posterior superior canal wall. A simple

mastoidectomy, right, was performed at Mercy Hospital on the above date. The whole mastoid labyrinth was involved with frank pus and granulation tissue. Patient was discharged from hospital on the fourth day following first dressing. Dressings were continued in the office.

Case 2: J. D., girl, age 6 years. Had measles one month previously. Both ears had been discharging copiously following paracentesis by a pediatrician. On March 13, 1928, a large swelling suddenly appeared behind the right ear. This was definitely a subperiosteal abscess. On March 14, 1928, a simple mastoidectomy, right, was performed at Mercy Hospital. Involvement of the mastoid was complete. A urinalysis one week before was negative. On this date it was loaded with albumin, red cells and casts. This acute kidney complication made prognosis a bit graver. Consideration for this, postponed operative treatment of the left mastoid, although it was recognized as being involved coincidently with the right. By April 5, 1928, however, further postponement could not be permitted. Consultation showed a flare-up in temperature, swollen eyelids, urinary findings, etc. Accordingly, a simple mastoidectomy, left, was performed. This was done under gas to save the kidneys. The left mastoiditis was evidently concerned in the kidney complication, because the latter promptly cleared up immediately following and has remained so. Due to the patient's precarious physical condition, plus kidney complication, patient was not discharged till 10 days later. Dressings were continued in the office.

Case 3: B. D., girl, age 8 years. Patient lived out of town. Had been under treatment for four weeks before admission to hospital, with running ears following influenza. Observation over several days developed exquisite mastoid tenderness on both sides with profuse, purulent discharge. On March 26, 1928, a shiny swelling showed over left mastoid. This was a subperiosteal abscess. On this date a simple mastoidectomy, left, was performed at Mercy Hospital. In addition to extensive involvement of the whole mastoid labyrinth, a perisinus abscess was encountered. Recovery was prompt. Patient was discharged from hospital on the fifth day following operation. Dressings were continued in the office.

Case 4: J. B., a man, age 30 years. On March 26, 1928, patient came in with pain and swelling in the left mastoid. The left ear had been discharging profusely for four weeks following influenza, although the swelling behind the ear had been noticed only in the past 24 hours. The swelling was obviously a subperiosteal abscess. On March 27, 1928, a simple mastoidectomy, left, was performed at

Mercy Hospital. Unusually extensive involvement of the tip and lateral sinus region was encountered. The latter was exposed for 1 inch but found to be normal. Patient was discharged from hospital the fifth day following operation. Dressings were continued in the office.

Case 5: B. H., a girl, age 4 years. Patient was first seen on March 26, 1928, with a swelling in left mastoid region. This swelling had been noted by mother during the past 48 hours, although left ear had been running for the past four weeks, following influenza. A subperiosteal abscess was apparent. Accordingly, a simple mastoidectomy, left, was performed at Mercy Hospital on March 26, 1928. Rather extensive involvement was encountered, though no unusual findings. Patient was discharged on fourth day following operation. Dressings were continued in the office.

Case 6: M. K., girl, age 22 years. The circumstances in this case are peculiar. On March 9, 1928, a T and A was performed at Mercy Hospital under gas. In the course of her convalescence a sinusitis, acute, suppurative, bilateral, developed. We have every reason to believe that this was due to influenza. Shortly after, the left eardrum became red and bulging. This was paracentesed. The left ear discharged profusely for the next three weeks. At this time, patient complained of so much mastoid pain and tenderness, together with loss in weight and strength, that operation was deemed necessary. On April 4, 1928, a simple mastoidectomy, left, was performed at Mercy Hospital under gas. The whole mastoid was found to be nothing more than a hollow shell filled with pus. A most peculiar canal was definitely cut through the bone from the tip to the antrum. Its diameter was 3 to 4 m.m. The occiptal cells were also unusually developed and involved. In fact, it was necessary to extend the original incision backward at right angles for fully 2 inches. Patient was discharged on the tenth day following operation. Dressings were continued in the office. Here, a Bezold threatened for days, but was obviated by discreet packing through the original operative wound deep down and behind sternomastoid muscle.

Case 7: R. H., boy, age 6 years. Patient was first seen on April 3, 1928. Mother had noticed a swelling behind the right ear for two days previously. A paracentesis had been performed four weeks previously. The ear had discharged for three weeks immediately following, and had then been dry for a full week before admission. The case was evidently a walled-off mastoiditis with a subperiosteal abscess. On April 4, a simple mastoidectomy, right, was performed at Mercy Hospital. A definitely hollowed out cavity filled with

frank pus surrounded the lateral sinus. The latter was covered with a pyogenic membrane but pulsated normally. The antrum was found apparently normal. Patient was discharged on the sixth day following operation. Dressings were continued in the office.

Case 8: K. V., girl, age 11 years. According to the mother's statement the right ear has been discharging practically since infancy. We saw this patient several times in the past two years. The discharge from the right ear has always been profuse and foul smelling. On May 7, 1928, patient was transferred to Mercy Hospital by her physician, who diagnosed an acute (super-imposed on a chronic) mastoiditis following influenza. An obvious subperiosteal abscess was present. On May 8, 1928, a simple mastoidectomy, right, was performed. Apart from the abscess mentioned, a small canal was easily demonstrable through the cortex connecting the above abscess with a hollowed out cavity full of foul smelling pus that bathed the lateral sinus. The mastoid, in fact, was nothing more than a hollow shell. This perisinus abscess had been accompanied by several chills lasting as long as 15 minutes. The lateral sinus was exposed for more than 1 inch and found to be covered by a pyogenic membrane, though still pulsating. Patient was discharged from the hospital on the fourth day following operation. Dressings were continued in the office.

Summary: 1. Of these nine mastoidectomies, three occurred in adults and five in children following influenza. The single exception was the measles case. The latter had a double mastoidectomy and a complicating Bright's disease.

2. It is interesting to note that of nine mastoidectomies performed, six had subperiosteal abscesses. One of these had a dry middle ear and proved to be a closed empyema of the mastoid. Three cases proved to have perisinus abscesses. All showed extensive involvement.

3. None developed any further complications, but proceeded to uninterrupted recovery.

4. Of the 63 ear cases, there were, in addition to these nine mastoidectomies, a number of definite mastoid involvements which later resolved under treatment and did not come to operation. Five of these cases were particularly outstanding. One, at least, had a severe complicating acute Bright's which cleared up when the middle ear and mastoid became dry. All dragged along 6 to 8 weeks, which is a longer wait than is usually considered consistent with good judgment. Good reasons, however, existed in each case for the delay.

This would indicate that, unless one's hand is forced, further delay under observation may obviate the necessity of operation.

5. The question of the postoperative length of hospital stay after mastoidectomy seems important. We recognize that every mastoidectomy is a law unto itself. It is ridiculous on the face of it to discharge a patient from hospital before it is safe, for here there should be no trifling with life and death. On the contrary, there is no need to keep a patient in hospital longer than is necessary. In certain mastoidectomies which are further complicated, it is obvious that a prolonged stay may be made necessary. In the average mastoidectomy, however, we have taken sharp exception to the keeping of a patient in hospital for 10 days to two weeks or longer. It is often unnecessary and expensive. We feel we shall be criticized for this viewpoint. Results, however, will speak for themselves. All things being equal, our practice is to discharge the patient from hospital immediately after the first dressing on the fourth day. Further dressings are continued in the office.

6. Another point, which has always been more or less of a hobby with us in our mastoid operations, should be emphasized. This is the attempt at securing a decent cosmetic result. The prime object in mastoidectomies has seemed always to be recovery without especial concern for the later appearance of the wound. In our opinion, this is not sufficient. Many patients have depressed and disfiguring mastoid scars that often prove embarrassing. We believe that the surgeon should regard himself as the master of the situation. He should be bold enough to dictate the result without leaving it entirely to chance. Without jeopardizing the safety of the patient, periosteum and skin edges can be so approximated at operation and postoperative handling so manipulated as to leave very little or no later disfigurement. In these few cases, attention to cosmetics has been well to the fore. The cosmetic results obtained in them have been highly satisfactory. A single exception is in the measles case, where, due to the very nature of the disease and its complications, free drainage was the sole consideration.

222 Michigan Street.

A NOVEL AND SIMPLE METHOD FOR THE DETECTION OF SIMULATION OF UNILATERAL DEAFNESS.

Dr. B. M. Becker, New York.

To the shallow cup of a Bowles' stethoscope, or any other similarly constructed instrument, a piece of soft rubber tubing, 12 inches long, is attached. In the distal end of the tube, insert the metal or hard rubber bifurcated piece, and to each end attach a soft rubber tube, one 12 inches in length, the other 24 inches, fitted with proper size ear pieces.

The next thing necessary is a ticking instrument, such as a watch, clock, metronome, etc.

The test consists in first ascertaining that the patient hears distinctly the ticking of any of the instruments through the longer tube when it is inserted in his normal ear, and the diaphragm of the stethoscope is placed directly on the surface of the ticker or in its immediate vicinity.

Care must be exercised in the choice of the sound-producing mechanism. If it is too loud, its sound will be heard outside the tubes and thus vitiate the test. If it isn't loud enough, it will necessitate shortening the tubes, making it inconvenient by working too close to the patient's ears.

The test depends upon two facts, either of which can be used for testing purposes. *1.* The first principle is that when tubes of unequal length are used and we listen to anything through them, the sound will always be lateralized on the side of the shorter tube. The sound through the longer tube is completely masked so that we are aware of monaural hearing, whereas the hearing is actually binaural. *2.* The second element in the test depends upon the fact of binaural hearing. For when you pinch or compress the longer tube through which apparently no sound reaches the ear, one immediately becomes aware of a decided change in the sound in the opposite ear, due no doubt to the fact that binaural hearing has been converted into monaural hearing.

Editor's Note: This ms. received in The Laryngoscope Office and accepted for publication May 31, 1928.

After we have satisfied the above conditions with respect to the tubes and ticker, we may proceed with the test. We may use the direct or indirect method.

The indirect method consists in that we apparently test the normal ear. The doctor stands behind the patient and inserts the shorter tube in the normal ear, and the longer tube in the supposedly deaf ear. Assuming the left is normal, the right, deaf; apply the stethoscope to the watch, etc., and asked the patient if he hears anything, and where. He will promptly answer that he hears the tick of the watch in the left ear. Now you ask the patient to tell you when he notices a change in sound. You compress the longer tube. He says that the sound changed; it is less pronounced and seems to approach nearer the eardrum. Then you know he is malingering, for if the right ear is deaf there is no change in sound perceived through the shorter tube. If the patient perceives no change in sound, we may resort to the direct method.

The order of the tubes is reversed, the short one in right ear, the long one in opposite. You ask the patient the same question. If he says he hears nothing, for he hears nothing with the normal ear, and he cannot commit himself by admitting that he hears the sound in the deaf ear, then we know he is malingering. Because if his right ear is deaf, he will hear the sound distinctly through the longer tube. If he is a cunning malingerer and in answer to the question he states that he hears the sound in the left ear, then you gradually compress the longer tube, thereby cutting off all sound from left ear, and if he still hears it, then he is exposed. You may compress the longer tube prior to insertion and ask if he hears a sound. If he hears it, then he is exposed; if not, you gradually decompress tube, and if he still does not hear it, then he again has been exposed. Thus by compression and decompression of longer, or even of short tube, before or after insertion you may modify the test to suit the particular occasion.

New York Post-Graduate Medical School and Hospital.

AGRANULOCYTIC ANGINA.

DR. WM. C. HUEPER and DR. DENO O'CONNOR, Chicago.

The agranulocytic angina first described by Türk[1], in 1907, and later claimed by Schultz[2], who reported, in 1922, a series of cases as a new disease (agranulocytosis) is apparently not frequently seen in this country, if a conclusion in this respect can be drawn from the number of reports published in the American literature representing about 15 per cent of the total number of cases, about 125. By far the majority of cases are recorded in Germany and Austria, about 100, while all other countries figure only with one or a few cases. But since the last year this disease is evidently on the increase in this country. About 50 per cent of the American cases were reported in 1927. During the time from November, 1927, to April, 1928, five additional cases came to observation in Mercy Hospital.

Case 1: Miss F. felt easily tired in recent months. Two days before admittance she became suddenly sick with sore throat, high fever, headache, extreme weakness, pains in back and limbs. A chill occurred on the first day of sickness. On admittance, Jan. 31, 1928, the patient was highly toxic, could only whisper, had dyspnea and frequent coughs, expectorating a fetid mucoid material. She is unable to swallow. Upon examination of the throat a large ulcerated area was seen involving the left tonsil and the posterior end of the soft palate and covered by a whitish membrane, which could not be scraped off and which was surrounded by a blackish zone. There was no evidence of injection in the adjacent tissue or elsewhere in the throat. The breath was foul, with an odor of dead flesh. Cervical lymph nodes were not enlarged. Lungs had normal breath sounds. Several hours before death râles in the back were heard. Heart findings were normal. The liver was enlarged. Its lower edge was palpable four fingers below the costal margin. Spleen was not palpable. No rigidity or tenderness of the abdomen except over the liver on percussion. The general condition grew rapidly worse. The ulcerations in the mouth extended also to the pillars and base of tongue. The sputum was yellow and mucinous. A throat smear showed many fusiforme bacilli and spirilli, short chains of streptococci, encapsulated pneumococci. Blood culture rendered hemolytic streptococci. The temperature varied between 100-102° F., and the pulse between 116-138. Urine examination showed albumin + and

a few leukocytes, erytrocytes and many epithelial cells in the sediment. Blood, Jan. 31, 1928: Leukocytes, 1,100; neutrophils, 16; lymphocytes, 76; monocytes, 4; basophils, 4. Feb. 1: Hemoglobin, 80 per cent; erythrocytes, 3,900,000; leukocytes, 600; small lymphocytes, 55; large lymphocytes, 45. Feb. 1: Leukocytes, 200; lymphocytes, 100 per cent. Feb. 1: Leukocytes, 100.

Death: Feb. 1. Autopsy, Feb. 1: Body of a woman, age 43 years, well nourished. Lungs were well distended, covered by a pleura which was smooth and glistening, except on small, retracted, irregular, dark red areas, where a thin fibrinous coat was present. Small subpleural hemorrhages were frequent. On the cut surface the lungs appeared hyperemic and edematous and contained especially in the lower lobes numerous irregular-shaped, dark red, firm, somewhat dry foci. The bronchial mucosa was thickened, red and covered with a bloody mucus. Heart and pericardium were normal. The mediastinal lymph nodes were anthrakotic and enlarged and grayish-red on the cut surface. The liver was enlarged, especially over the gall bladder region. Besides cloudy swelling there was no other pathological finding. The spleen was moderately enlarged, dark red, firm, with a smooth surface. On the cut surface the follicular structure appeared to be indistinct. There were several yellowish-white, firm, round, well circumscribed nodules of buckshot size in the splenic tissue. The stomach was contracted and showed numerous fresh hemorrhages in the mucosa. The intestine was normal. The mesenteric lymph nodes were enlarged and grayish-red. The adrenal glands were gray throughout. The left ovary contained a fresh corpus hemorrhagicum. The uterus was filled with a small amount of blood and lined by a thickened and hyperemic mucosa. The kidneys were swollen. The capsule stripped easily. The surface was smooth and brownish-red. Numerous pinhead-sized points were seen in the cortex. The cortex and medulla were indistinctly demarcated. The bone marrow of the right femur was red. The base of the tongue, the tonsils, the pillars, the epiglottis, the aryepiglottic folds, the right vocal cord and the lower part of the pharynx showed numerous irregular, partly deep ulcerations, covered frequently by a yellowish to greenish-black coat, surrounded by a wine-red zone. The trachea and the esophagus were normal. The thyroid gland was somewhat enlarged and had an indistinct follicular structure. The blood exuding from the vessels coagulated readily in large, dark red clots.

Microscopical Examination: Ulcer of pillar: The superficial layer of the bottom of the ulcer is composed of necrotic, granular material, intermingled with numerous bacteria. Underneath this mass necrotic

muscle tissue and acinar glands are present, with frequent large streak-like accumulations of bacteria in between the connective tissue. The vessels in this area contain hyaline, fibrinous and red thrombi. The absence of leukocytes in these thrombi is striking. In the still deeper layer where living and necrotic tissue are alternatingly found perivascular, lymphocytic and plasma cellular infiltrations are scantily observed. Hemosiderin pigment is present in the necrotic tissue, which shows as the living tissue evidence of edema.

Thyroid gland: This organ is composed of rather small follicles lined by a low cuboidal epithelium and filled by a pink-stained colloid. There are numerous interstitial lymphocytic infiltrations present.

Lung: The lung tissue in the dark red, solid foci shows alveoli completely filled with erythrocytes. The alveolar capillaries are hyperemic. In the hemorrhagic content bluish masses of bacteria are occasionally seen. The adjacent alveoli contain an albuminous or fibrinous exudate. Heart failure cells are frequently present in these alveoli. The absence of leukocytes in these extravasations is prominent. The alveoli in the periphery of these foci show evidence of compensatory emphysema.

Liver: The liver is edematous and its vessels are hyperemic. The liver cells are swollen and contain frequently brownish bile pigment. Bile casts are present in the bile capillaries. A moderate fatty degeneration of the liver cells exists around the central vein. The Kupffer's cells are distinctly increased in number. There are intracinar hemorrhages in moderate number and interstitial lymphocytic infiltrations scantily found.

Stomach: The hemorrhages in the mucosa affect usually only the tips of the folds and do not extend into the submucosa. The tissue covering them is necrotic.

Spleen: The follicles are small and composed of mature lymphocytes. The germinative centres are absent. The sinuses are distended and filled with endothelial cells, erythrocytes and scanty lymphocytes. There are small, round, anemic infarcts present, surrounded by an increased connective tissue. The large veins contain besides erythrocytes, plugs of lymphocytes and large, round or polygonal cells (endothelial cells?).

Lymph nodes: The periaortic, peribronchial and mesenteric lymph nodes show atrophic lymph follicles, lack of germinative centres and a hyperplasia of the resticuloendothelial cells. Leukocytes are absent.

Kidney: The glomeruli are swollen and hyperemic. The tubular epithelium is extensively degenerated and necrotic. The lumina are filled with cellular detritus and stringy, albuminous material.

Suprarenal gland: There are scanty cortical hemorrhages.

Uterus: The endometrium is in the menstrual stage.

Bone marrow: In the fat marrow large islands containing erythrocytes, erythroblasts, megakaryocytes, monocytes, plasma cells and lymphocytes are found. Segmented nucleated leukocytes and their immature forms are absent.

Skeleton, diaphragmatic and heart muscle, pancreas, aorta, ovary and tube are without pathological findings.

Rabbits injected with an ascites-bouillon culture of the hemolytic streptococci obtained from the blood of the patient showed a drop of the neutrophilic leukocytes from 35 per cent to 18 per cent in five days and an increase of the number of leukocytes from 5,200 to 9,200. The animals stayed alive.

Case 2: Miss S. I., age 52 years, had rheumatism for many years up to 1910, when a tonsillectomy was performed. In 1919, she had an ulcer of the stomach and severe jaundice. Since that time she had rarely attacks of sour belching, accompanied by loose stools. Nocturia existed during the last eight or ten years. She took suddenly sick one day before admission, Feb. 25, 1928, with sore throat, heart palpitations, dizziness, cramp-like pains over the gall bladder region, radiating into the left scapula and across the back, and swelling of the cervical glands. The pains in the gall bladder region were transitory and sharp. The physical examination rendered following findings: The pharyngeal region was reddened. A fetid foetor ex ore was noticed. The fossae of the tonsils were clear. The thyroid gland was palpable and the cervical glands somewhat enlarged. The heart was enlarged to the right side. The blood pressure was 115/65. The pulse was rapid and of poor quality. The lung findings were normal. The abdominal wall was moderately rigid and throughout tender on moderate pressure, especially over the gall bladder region. A freely movable lipoma was located over the left scapula. No jaundice was observed. On the second day she had several chills and headache. The throat was very sore. This condition was prevailing during the first four days (temperature between 100-103° F., pulse between 80-110). On the fifth day she felt much better and had a normal temperature and pulse rate, but still a sore throat and epigastric pains. On the ninth day she became suddenly restless, dizzy, nauseated and coughed frequently, vomited several times, perspired profusely and had pains in the left side and an irregular pulse going up to 120, together with an increase in temperature to 103-104° F. On the following day her general condition grew rapidly worse. Grayish coats appeared in the tonsillar fossae and a purple-

colored nodule at the base of the tongue (hemorrhage?). The temperature was for some time above 105° F. and the pulse rate was 128. There was considerable dyspnea. The abdomen was distended; the stools were liquid, and the patient complained about distressing pains in the abdomen. Death on March 7, 1928. Blood culture was negative. Throat smear showed streptococci and staphylococci. Blood: Erythrocytes, 3,600,000; hemoglobin, 70 per cent; leukocytes during the first days, 2,400; differential count: neutrophil leukocytes, 1; lymphocytes, 95; basophil leukocytes, 4. During the remission the number of leukocytes was found to be between 2,500-2,800, with 41-58 per cent neutrophil leukocytes. After the remission the leukocytes count dropped to 1,000, with no neutrophil cells. The examination of the urine showed always albumin +, sugar +, and in the sediment rarely leukocytes.

During the first days of her illness the diagnosis " acute attack of a chronic cholecystitis" was considered, but the blood findings, the striking discrepancy between the relatively light local findings in the gall bladder region, and the very bad general condition of the patient and the presence of a sore throat led to the diagnosis "agranulocytic angina".

Case 3: Mr. W., age 79 years, who was feeling weak since he recovered from a pneumonia last February, was admitted on April 3, 1928, on account of an urinary incontinence. The physical examination at that time did not render any pathological findings except those concerning the enlarged prostate gland. A retention catheter was inserted the same day. On the following day he complained about a sore throat, dyspnea, great weakness and was slightly jaundiced. On the third day an ulceration on the anterior pillar was observed. He had a fetid odor from the mouth and difficulties in swallowing. Two days later there was a yellowish coat on the tonsils and more extensive ulcerations. His condition grew rapidly worse and he died on the sixth day of his illness. The temperature varied between 100-102° F. In the urine was albumin + and in the sediment were rarely leukocytes, many erythrocytes. Blood: Culture was negative, erythrocytes, 3,900,000; hemoglobin, 75 per cent; leukocytes, 2,100; differential count: neutrophils, 2; lymphocytes, 92; monocytes, 6. Blood chemistry: Urice acid, 3, 8; creatinine, 1, 5; urea, 47, 8; urea nitrogen, 22, 2. The number of erythrocytes and the amount of hemoglobin did not change after the initial count. The number of leukocytes dropped, however, to 150 on the last day following a radiation of the femurs with stimulating doses of Roentgen rays. The neutrophils disappeared completely from the blood after the third day.

Blood chemistry on the last day rendered: N. P. N., 38, 7; urea, 51, 3; urea N., 24; creatinine, 1,575, and uric acid, 4, 4. The diagnosis was chronic hydronephrosis and agranulocytic angina.

Case 4: Miss W., age 38 years, had been in the hospital for three weeks for gastrointestinal examination. She left the hospital Nov. 10, 1927, feeling well; temperature, 98° F.; pulse, 80; respiration, 20. A few hours after leaving the hospital she began to feel ill, had general malaise, pain in the throat, which rapidly became worse, being so severe that she did not sleep all night and was so ill the next morning that she returned to the hospital. On entrance examination it was noted that there was a slight icteric tint to scleras. The tonsils were enlarged, covered with small gray patches, which were adherent and could not be removed readily, leaving a bleeding surface when touched. The pillars of the tonsils were edematous. The pharynx was injected and very red. There was a marked tenderness at the angle of both jaws. Heart and lungs were normal. Temperature at admission was 103.6° F. The blood examination rendered following findings: The leukocyte count was 1,625, with 58 per cent neutrophilic leukocytes and 42 per cent lymphocytes; 4,200,000 erythrocytes, 80 per cent hemoglobin. A smear from the throat showed streptococci, staphylococci and pneumococci. The general condition grew rapidly worse. The tonsils became so enlarged that she could scarcely swallow. There was difficulty in breathing and marked toxicity. The temperature varied between 101.6° and 104.0° F. The blood findings were unchanged in regard to the red blood picture. The leukocyte count showed 1,400 cells. Urine examination was negative. The patient died on the fourth day.

Autopsy: Body of a well nourished woman. Peritoneum was smooth and glistening. The liver was somewhat enlarged, brown-red, with indistinct acinar structure and turbidity on the cut surface. Gall bladder, pancreas, intestine were normal. The stomach showed multiple streak-like hemorrhages in the mucosa. The spleen was also somewhat enlarged, firm in consistency, and showed indistinct follicles on the cut surface. The kidney represented evidence of cloudy swelling. The mesenteric and retroperitoneal lymph nodes were enlarged, medullary and reddish-gray.

The microscopical examination of the abdominal organs rendered similar histological changes of the liver, spleen, kidney and lymph nodes, as described in Case 1.

Case 5: Mr. A., age 43 years, took sick suddenly with fever, sore throat. He was first seen on the third day of his illness, January, 1928. The physical examination showed that the tonsils were large,

edematous and had grayish-yellow patches. The glands on both sides of the neck were moderately enlarged. There were numerous not quite superficial lesions with hardened edges on the lips, nases and chin. The temperature was 102.4° F. The leukocyte count was 3,000, which dropped later to 1,200. He was acutely ill and unconscious for two weeks. Then he improved gradually and gained strength slowly till he was able to be up and around. He went to Florida for a period of rest and finally returned to work. But his leukocyte count was at no time over 3,400. He had a recurrence at about 4½ months from onset of the disease which proved rapidly fatal. The leukocyte count at this time was as low as 800.

The therapeutic procedures in all five cases consisted in local applications of the common disinfectants and administration of arsenic compounds. Streptococcus antiserum was given in two cases, intramuscular injection of blood in one case and radiation of the long bones with stimulating doses of Roentgen rays in another case without any favorable effect. But it has to be noted that the last mentioned therapeutics were administered at a rather late stage of the disease.

COMMENT.

The first three of the reported five cases are in their symptomatology and pathology very similar to those described by Schultz. The diagnosis of the last two cases cannot be regarded as definite on account of insufficient clinical and pathological data. But at least they are highly suspicious of this disease. All five cases took a fatal course. Three women and two men were involved. The ratio of frequency between women and men is according to our investigations 3.5:1. The age varied from 36 to 79. There was no evidence of any contagiousness observed. The investigations made on our cases do not allow any positive contribution to the question of etiology. The infectious origin and septic character of the disease as asserted by numerous authors seems to us not proven. The presence of streptococci or other bacteria in the blood is not considered by us as a primary condition, but as a secondary one due to an invasion of these bacteria through the necroses in the mouth, as also observed in leucemias. The unknown toxic element active in this disease does not only injure the granulocytic system but also the lymphatic one, as evident from the marked absolute decrease of the lymphocytes in the blood and the atrophy of the lymphatic tissue in the spleen and the lymph nodes. The reticuloendothelial cells seem to undergo a compensatory hyperplasia. All cases reported by other authors as "agranulocytoses" which developed this symptom complex following

a purulent infection—otitis media, sinus infection, endocarditis, cellulitis, lymphangitis, gluteal abscess, infected carcinoma of uterus, syphilitic ulcer of nasal septum, thrombosis of femoral vein, etc.—and showing evidence of suppuration, generalized hemorrhagic diathesis, secondary anemia, myelocytic reaction in the blood and bone marrow cannot be recognized as essential agranulocytoses, but are probably more correctly classified as septic infections with an agranulocytic symptom complex, which is also observed in many other diseases, as aleukia, pernicious anemia, abdominal lymphogranulomatosis, carcinosis of the bone, poisonings with benzol, salvarsan, Roentgen rays, thorium-X, etc.

We want to express our appreciation to Dr. Fred Drennan, Dr. Robert Berghoff, Dr. Carl Christoph for permission to use the histories of Cases 2, 3, 4 and 5.

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Mercy Hospital.

A NEW METHOD OF DETERMINING UNILATERAL DEAFNESS AND MALINGERING.*

DR. JOHN GUTTMAN, New York.

The determination of unilateral deafness is important not only from a theoretical point of view, that it enables us to be fullly informed about the function, or lack of function, of the ears of a patient, but the exact information concerning the function of each ear has also great practical value.

In an existing purulent otitis media it is from a prognostic as well as from a therapeutic viewpoint important to determine the exact time when the purulent process from the middle ear extended into the inner ear. This occurrence becomes manifest by the sudden and complete deafness of that ear. In cases of fracture of the skull or other head injuries, it may be from a forensic standpoint important

*Read before the Otological Section of the New York Academy of Medicine, March 9, 1928.

Editor's Note: This ms. received in The Laryngoscope Office and accepted for publication June 1, 1928.

to determine definitely total or partial deafness. The usual methods of determining deafness of one ear by the use of speech, tuning fork, or even audiometer, do not succeed easily, as the exclusion of the normal ear from hearing is very difficult.

The most common method to exclude the normal ear from hearing is to place a wetted finger or a Barany noise apparatus into the ear canal of the normal ear. Neither the one nor the other nullifies completely the hearing from this ear. Bezold found that when a normal ear was properly occluded and an a (480) tuning fork was placed in front of the other ear, the labyrinth of which has been previously extirpated, the patient could still hear the tuning fork. His explanation of this phenomenon was that the sound of the tuning fork had been conducted to the normal labyrinth by means of bone conduction.

The noise apparatus in the good ear has also the disadvantage that it deafens not only the normal ear, but to some extent also the diseased ear, so that if a small remnant of hearing is left in the diseased ear this may even become extinguished on account of the noise apparatus. My method is founded upon the following physiological fact:

During the perception of one sensation a second sensation can be perceived contemporaneously only when the second sensation differs within certain limits from the first sensation quantitatively, qualitatively, or in both respects. The minimum difference needed for the contemporaneous perception of two sensations is called differential threshold.

When two tones of identical frequency and sufficiently great difference of intensity (about 5 T. U.) are introduced simultaneously, one in each ear, only the tone of the greater intensity will be heard and will be lateralized in that ear. Unilateral deafness by my method is determined in the following way:

The normal ear is not occluded, but on the contrary a tone is introduced into that ear by placing a telephone receiver which is connected with my audiometer and its threshold established. Then through a second receiver similarly connected, a tone of the same frequency is introduced into the deafened ear and its intensity increased until the tone in the normal ear is suppressed and the lateralization of the tone in that ear abolished.

This determines the threshold in the deafened ear. The detection of simulation rests upon the same reasoning.

987 Madison Avenue.

A SIMPLIFIED METHOD FOR X-RAY STUDIES OF THE ACCESSORY NASAL SINUSES.

DR. H. COULTER TODD, Oklahoma City, Okla.

X-ray study of the accessory nasal sinuses has not been altogether satisfactory. The use of lipiodol or other iodized oils, however, has added much to the results obtained.

The writer wishes to present a method which is so simple that any rhino-radiologist may use it, we believe, with great ease and considerable satisfaction. We will not ask for space to present cuts or illustrations. If our simple technique is followed anyone may easily produce his own pictures or make his own fluoroscopic observations. The technique is as follows:

1. Thoroughly cleanse the nose with a mild alkaline douche. Apply to the entire Schneiderian membrane a solution of 1 per cent ephedrin and 1 per cent cocain hydrochlorid, which will thoroughly open up all the sinus ducts and will sufficiently desensitize the nasal mucous membrane so the nose may be completely wiped out without causing any pain. Then apply sufficient suction as will empty all the sinuses of any fluid or pus they may contain.

2. Place the patient upon the X-ray table in the dorsal position so that the occiput rests over the sensitive X-ray plate, making the angle of the occiput with the trunk such that sufficient lipiodol may be dropped into each nostril to cover all the nasal openings of the sinus ducts without much, if any, of the oil passing into the nasopharynx, the patient keeping the mouth open and breathing through it all the while. Small cushions may be placed under the patient's shoulders so he may be made to rest comfortably. The angle of the occiput with the trunk should be a little less than 45°, depending upon the location of the middle meatus as observed by the rhinologist.

3. Remaining fixedly in this position after ½ to 1 dr. of the lipiodol has been dropped up each nostril, depending upon the size of the nasal cavities, the patient is instructed to sieze the nose tightly between the thumb and index finger of the right hand and exhale deeply. Then with the mouth and lips closed tightly, slowly but with all the strength possessed, ask the patient to attempt to pull air into the emptied lungs through the tightly closed nose. This will produce a vacuum in all the sinuses. While thus attempting to

Editor's Note: This ms. received in The Laryngoscope Office and accepted for publication July 5, 1928.

breathe in through the closed nose, have the individual suddenly to relax his hold upon the nose, when the air will rush in. This procedure must be repeated from 5 to 15 times while the rhinologist continues from time to time to drop more lipiodol into each nostril. The effort to inhale with the nostrils closed produces a vacuum in the nose and accessory sinuses. When the fingers are removed quickly from the nose while the patient is at the height of his effort to inhale, air rushes in and as the openings of the sinus duct, which have been enlarged by the adrenalin and cocain, are covered with the oil, the lipiodol is carried into the sinuses with the inrushing air. By adding more lipiodol and repeating the process the sinuses may thus be most readily and easily filled with the liquid for study, either by the fluoroscope or with the X-ray picture. This procedure is especially valuable in the study of the ethmoids and the sphenoids.

It must be remembered that the patient must be kept in the dorsal position continuously during our study, otherwise the oil will flow out by gravity. After filling the sinuses and before using the fluoroscope or X-ray pictures, the nasal cavities should be thoroughly cleared of all excess of the oil by using sterile cotton upon nasal applicators. This is not unpleasant to the patient because of our previous use of the cocain.

X-ray pictures may be taken at the Granger angles, but they must be taken postero-anteriorally rather than antro-posteriorally. The angles can readily be found by measuring the angle of the occiput with the trunk. This is such a simple procedure that we feel sure if it has not already occurred to the reader, it will be found very helpful in all studies of the accessory nasal sinuses, either in the normal or pathological states. As we stated before, it is especially helpful in the study of the ethmoid and sphenoid sinuses.

308-310 Colcord Building.

ST. LOUIS MEETING OF THE AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY.

The American Academy of Ophthalmology and Oto-Laryngology, at its annual convention in St. Louis, Oct. 15 to 19, elected the following officers:

President—Dr. Harris P. Mosher, Boston.

President-Elect—Dr. Wm. H. Wilder, Chicago.

First Vice-President—Dr. Frank E. Burch, St. Paul.

Second Vice-President—Dr. Harry W. Lyman, St. Louis.

Third Vice-President—Dr. John H. Dunnington, New York.

Treasurer—Dr. Secord H. Large, Cleveland.

Editor of Transactions—Dr. Clarence Loeb, Hubbard Woods, Illinois.

Executive Secretary—Dr. Wm. P. Wherry, Omaha.

Secretary for Ophthalmology—Dr. Wm. L. Benedict, Rochester, Minn.

Secretary for Oto-Laryngology—Dr. John Myers, Kansas City.

Secretary for Instruction—Dr. Harry Gradle, Chicago.

There were seven hundred and forty-nine members registered.

The scientific program, as well as the clinical conferences, were enthusiastically received. The conferences—some 61 in number—were practically filled to capacity.

Four thousand dollars was appropriated for research for the year. Dr. D. B. Kirby, of New York, received the grant for Ophthalmology, and Dr. W. J. McNally, of Montreal, the grant for Oto-Laryngology.

One hundred and one members enjoyed the golf tournament, which was declared to be the best ever attempted, Dr. McKee, of Pittsburgh, winning the St. Louis cup.

One hundred and forty-seven new members were elected, bringing the membership to over 1,600.

Atlantic City was selected as the meeting place for 1929.

FIRST INTERNATIONAL OTO-LARYNGOLOGICAL CONGRESS.

An epoch-making event, the First International Oto-Laryngological Congress, was held in Copenhagen, July 30 to August 1, with an attendance of over 400 Congressists, representing every country and nation active in these medical specialties.

Guided by the versatility, amiability and experience of such able veterans as Schmiegelow and Mygind and the Danish Committee, held under the auspices of a neutral and democratic nation in beautiful Copenhagen, participated in by the Masters of Oto-Laryngology from all points of the compass, this Congress proved a brilliant success and paved the way substantially to a better understanding and closer co-operation in the further development of these important medical specialties.

For many years, even preceding the period of the World War, there had been active controversies and individual opinions on the advisability of uniting Otology and Rhino-Laryngology in an International Congress and the Copenhagen Congress proved beyond further discussion the happy possibilities of such a union. There still obtains in some countries, especially in Germany and Austria, some line of demarcation in conclave between Otology and Rhinology, but gradually the older differentiations are being mollified or even obliterated and more recent triological understanding is taking place.

A bit of historical prelude may be of interest. The first International Otological Congress was proposed by the American Otological Association and held in New York, in 1876; the second International Otological Congress was in Milan, in 1880; the third, in Basel, in 1884; the fourth, in Brussels, in 1888. There was an effort to unite these specialties in a combined Congress in Paris, in 1889, on the occasion of the International Exposition there, but this Congress was held at the instance of the French Ministry and not of an International Oto-Laryngological Committee. There followed the International Otological Congresses at Florence, in 1895; London, in 1899; Bordeaux, in 1904; Budapest, in 1909, this being a Section of the International Medical Congress there. The last International Otological Congress preceding the World War was held in Boston, in 1912.

The first International Laryngological Congress was held in Milan, in 1880. International Laryngological Conclaves were temporarily discontinued when it was conceded that the Laryngologists would be assigned an independent Section at future International Medical Congresses, and thus the Laryngological Section met at International Medical Congresses until the second independent Laryngological Congress was held in Vienna, in 1908, in connection with a memorial celebration commemorating the pioneer contributions to this specialty by Czermak and Turel. The Third International Laryngological Congress was held in Berlin, in 1911.

The war created a long lapse in these Congress activities. With the reunion of Otologist and Laryngologist recently concluded in Copenhagen there was formed a new scientific fellowship and the First International Oto-Laryngological Congress was realized. A permanent organization committee was established and the conduct of future similar Congresses was thus assured.

Scientifically, this Congress had its limitations, due to the crowding into three days' sessions of over 120 papers, the necessary time limitations in the presentation of these papers and their discussion and the arbitrary subdivision of the proceedings in three Sections. Profiting by the experiences of the Copenhagen Congress, future meetings no doubt will be adjusted to overcome these handicaps. To the critical observer, however, this Congress presented an excellent survey of the progress and contributions to Oto-Laryngology from all lands and one of the significant and dominant features was that of a better understanding and good fellowship than has ever before existed.

Socially, thanks to the generosity, grace, tact and administrative talents of the Danish Committee and the natural setting of beautiful Copenhagen, the First International Oto-Laryngological Congress was a glorious success, and so it will always be regarded by the consensus of opinion of the Congressists and their ladies.

Finally, one of the most valuable features of the Congress was the happy reunion of old friends from many lands, the cementing of new friendships and the breaking down of the arbitrary barriers between Otology and Rhino-Laryngology.

IN MEMORIAM.

WILLIAM SCHEPPEGRELL.

Dr. William Scheppegrell, of New Orleans, long established in that city as an Otologist and Laryngologist, died August 9, 1928, at Mercy Hospital, at the age of 67 years.

In 1889, Dr. Scheppegrell was graduated from the Medical College of the State of South Carolina and after a few years in general practice he specialized in Oto-Laryngology and continued actively in this field until a few years ago. He was the third President of the American Academy of Ophthalmology and Oto-Laryngology; Vice-President of the American Laryngological, Rhinological and Otological Society, in 19??; on the Staff of the Charity Hospital; formerly Co-Editor of the Annals of Otology, Rhinology and Laryngology, and for many years was Associate Editor of THE LARYNGOSCOPE, serving actively in this capacity during the pioneer period in the development of this journal.

Dr. Scheppegrell was a close student of the problems of Hay Fever; was one of the organizers of the National Hay Fever Society and author of an exhaustive treatise, "Hay Fever and Asthma: Cause, Treatment and Cure". He was a genial, cultured gentleman, an indefatigable reader and alert to the progress of many of the sciences correlated to medicine.

As Editor of THE LARYNGOSCOPE we wish to publicly express our acknowledgment and appreciation of his many years of service to the cause of Oto-Laryngologic Literature. To the family of our bereaved friend we extend our heartfelt sympathies.

DR. HARRY ROBSON HALL.

Dr. Harry R. Hall, of St. Louis, died July 25, 1928, at St. Luke's Hospital a short time after an infection from a carbuncle on the neck.

Dr. Hall was born in Chitanongo, N. Y., Feb. 3, 1871; he was a product of the St. Louis Public Schools, the High School, a graduate of Washington University, 1893, and of St. Louis University Medical School, in 1895. He served his interneship at the St. Louis City Hospital and the Female Hospital and practiced in general medicine until about twelve years ago, when he concentrated most of his professional activities on Oto-Laryngology, and was for many years an Assistant in the Oto-Laryngologic Clinic of St. Louis Jewish Hospital. He was one of the writer's close personal and professional friends, loyal and reliable, conscientious in the discharge of his professional responsibilities and an upstanding man of culture and refinement.

Always popular in the social circles in which he was a moving and kindly spirit; interested in the arts and sciences; a close and careful reader and student; sympathetic and unostentatious in his professional contacts; beloved by his colleagues and friends,—to his dear wife and family and the inner circle of friends with whom we have had the privilege of association for many years, we extend our most heartfelt sympathy.

DR. LEON EDWARD WHITE.

Dr. Leon E. White died in Boston, May 18, 1928, aged 60 years.

Dr. White was a graduate of Dartmouth Medical School, 1893; a member of the American Otological Society, the American Laryngological Society, the American Laryngological, Rhinological and Otological Society, the New England Otological and Laryngological Society and the American Academy of Ophthalmology and Oto-Laryngology. He was formerly Assistant in Otology at Tufts College Medical School and a member of the Staffs of the Massachusetts General Hospital and the Massachusetts Eye and Ear Infirmary. He was a Fellow in Otology, conducting courses for graduates at Harvard Medical School.

Personally Dr. White was a man of fine presence, modest bearing and kindly spirit; studious, painstaking and scientifically reliable.

Perhaps the most important contributions to medical literature which he made were his investigations of Optic Nerve Disturbances as Determined by Optic Canal Measurements, Radiographs, etc.